Brick & Clay

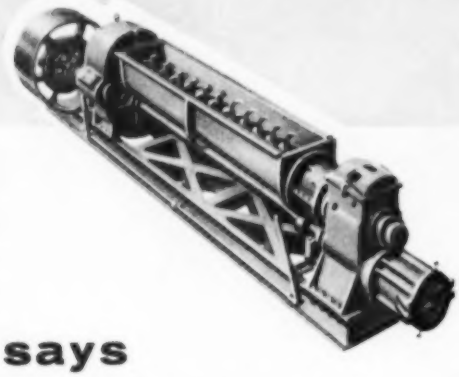
OCTOBER, 1959

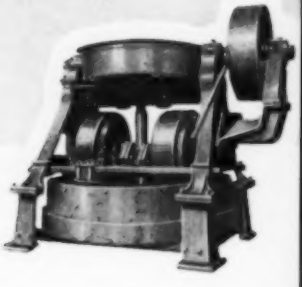
This Issue

"Clay Block Will Fire in Six Hours"-*Caruso*

Clay Modifiers for *Brick, Pipe and Refractories*

"Wonderful Workhorses,"





says

ALTON BRICK

- management
- production
- maintenance

in reporting on BONNOT units at Maryland Heights Plan

— PRODUCTION OF MORE THAN 50,000,000 BRICK WITHOUT ANY DOWN TIME EXCEPT FOR REPLACEMENT OF NORMALLY WEARING PARTS.

— GRINDING OF NEARLY 2,000,000 TONS OF SHALE AND STILL GOING STRONG

These are two big reasons behind the title of "wonderful workhorses" bestowed on a Bonnot Greyhound Extruder and a Bonnot 10-foot Dry Pan by the management-production-maintenance supervisors at the Maryland Heights Plant of the Alton Brick Company in St. Louis, Mo.

Experience with the Bonnot Dry Pan covers 20 years—over 5 with the Bonnot Extruder. In addition to profitable dependability for maintaining rugged production schedules, the Bonnot Greyhound is completely satisfactory with either steam or oil dies—for all sizes of brick. With the Bonnot Greyhound, Alton shale is processed more accurately because it's practical to hold a higher vacuum . . . operating efficiency is increased because of easy accessibility of "wearing parts."

Bonnot engineers and machines will provide the same manufacturing economies for your plant. At Bonnot, your problems will get prompt attention, with the accuracy of the answers based on know-how gained by more than 70 years of service to leading clay processors throughout the U. S. A. Call, wire or write today . . . for greater profits during "the Soaring 60's"!

PLANT MANAGER M. P. HALL CHECKS THE BONNOT "ABSOLUTE GAUGE" (CONTROL) WHICH HE FINDS EXTREMELY VALUABLE IN PRODUCING THE QUALITY-TEXTURED RED BRICK FOR WHICH ALTON'S MARYLAND HEIGHTS PLANT IS FAVORABLY KNOWN.

PRODUCTION MANAGER TED SCHUTTENBERG (LEFT) JOINS PLANT MANAGER HALL AFTER A "QUICK CHANGE" FROM STANDARD TO NORMAN DIE ON "THE BONNOT WORKHORSE."

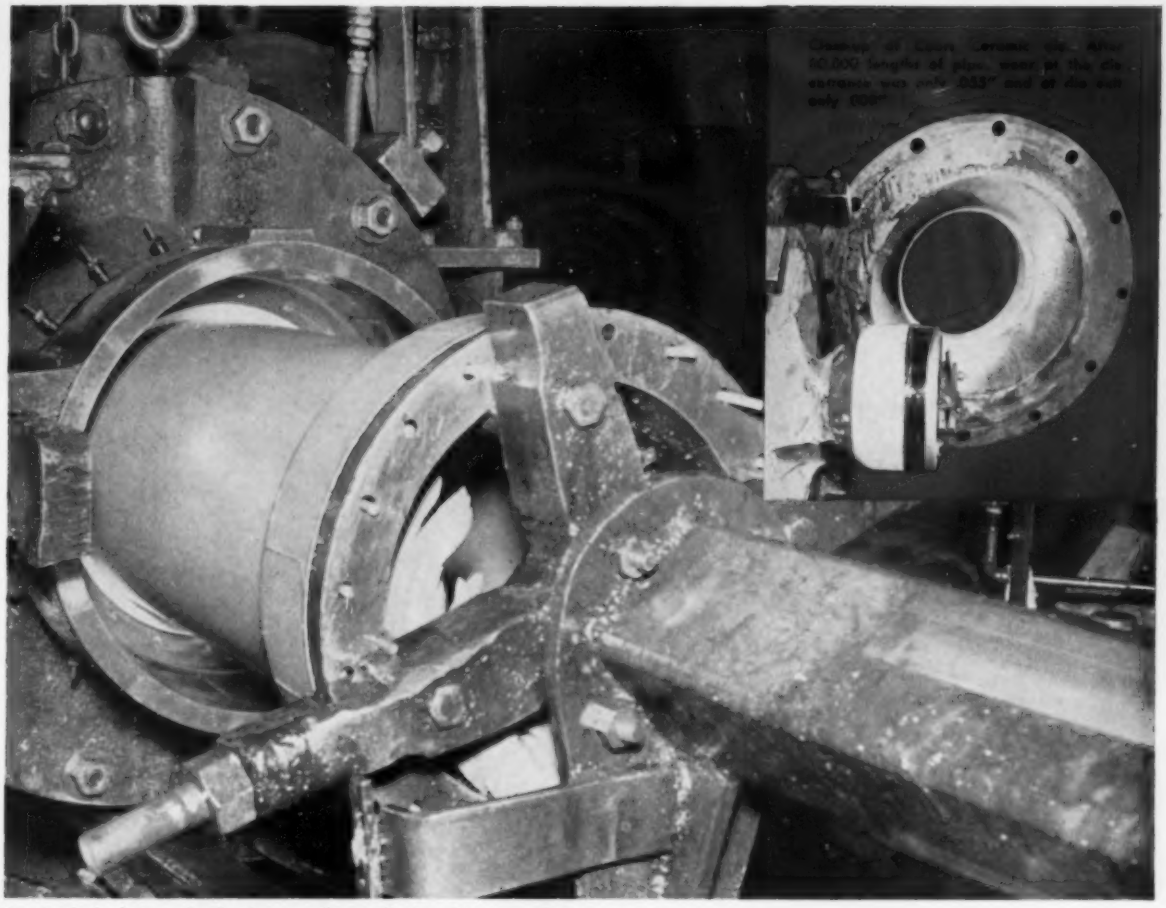
DRY PAN OR EXTRUDER, BONNOT MACHINES GET AN "AROUND THE CLOCK VOTE OF CONFIDENCE" FROM ASST. SUPERINTENDENT RUSS RICHARDSON, WHO REPORTS BONNOT EQUIPMENT "EASIEST TO HANDLE" IN HIS MANY YEARS OF CLAY-PROCESSING EXPERIENCE.

STEP AHEAD WITH BONNOT

The BONNOT Co.

CANTON 2, OHIO

CRUSHERS	AUGER MACHINES	
HAMMER MILLS	VACUUM MACHINES	
DRY PANS	SPECIAL EXTRUDERS	CUTTERS
WET PANS	PUG MILLS	REPRESSES
GRINDERS	SPECIAL MACHINES TO ORDER	DIES
FEEDERS	DIRECT FOUNDRY SERVICE	MIXERS



Unretouched photograph, showing smoothness of pipe skin even after 320,000 feet of 8" pipe had been extruded through the Coors Ceramic die.

PIPE DIES OF COORS CERAMIC OUTLAST METAL DIES 10 to 1

Production of over 100,000 lengths of 8" sewer pipe—400,000 feet of pipe—is the record-breaking output of the new die and bell liners used by the Denver Brick and Pipe Company, Denver, Colorado. These new liners are made of Coors High Alumina Ceramic, a high strength material that is extremely resistant to abrasion or erosion.

Formerly, cast iron dies produced only 4,000 lengths of pipe, case-hardened steel 9,000 lengths at most, and alloy steel only 6,000 lengths.

Now, with the Coors Ceramic liners, there is no significant increase in pipe weight even after production of as many as 80,000 lengths of pipe. This results in saving of clay. Skin texture of the pipe remains smooth—no scores, cracks or grooves.

The Coors Ceramic die and bell liners have not only provided a reduction in maintenance and replacement costs—the far longer life of the ceramic makes these dies economical to use.

Coors Ceramic Dies are providing these money-saving benefits:

• At least 140 cubic yards of clay saved between die liner changes • Pipe skin remains smooth for over 400,000 feet of pipe • Drier losses are cut • Ceramic dies are lasting 10 times longer than case-hardened steel... 17 times longer than alloy steel • Down time, maintenance and replacement costs have been substantially reduced.

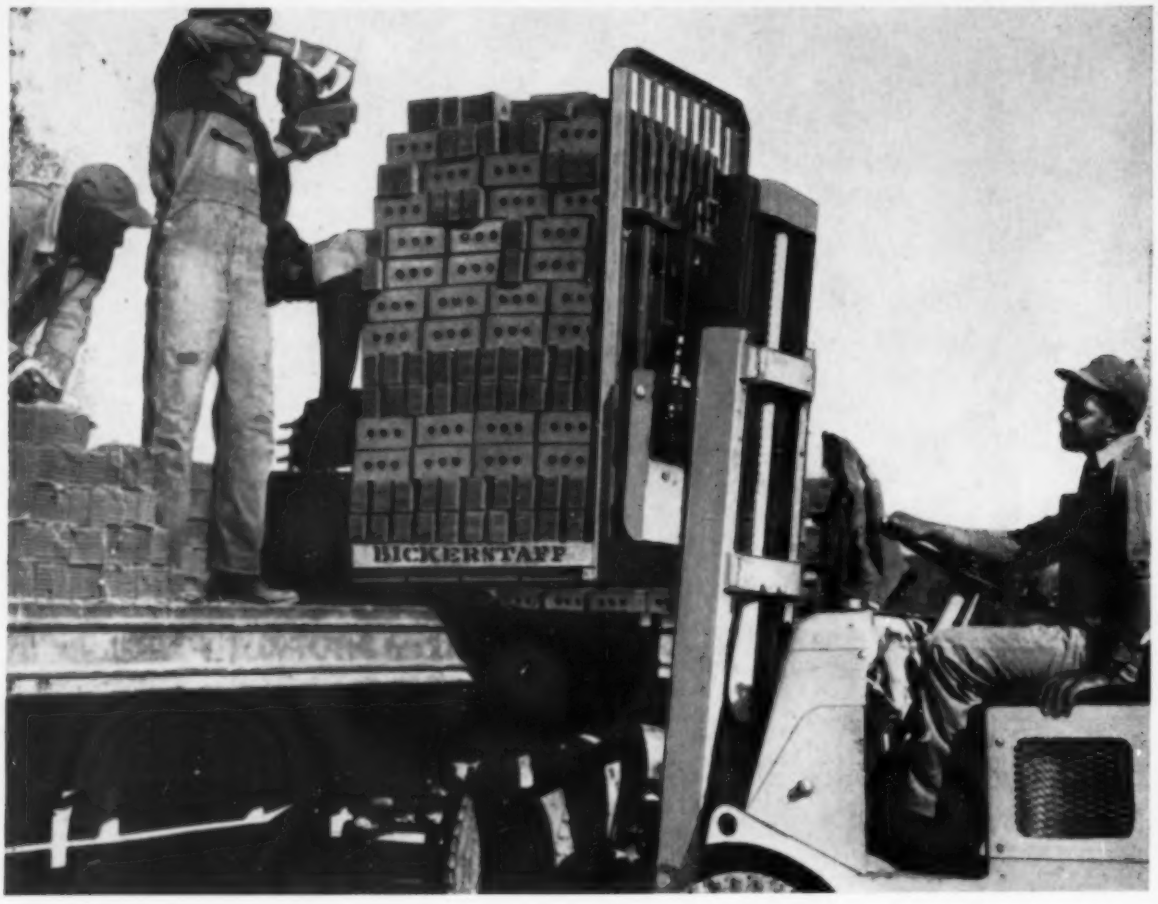
Your nearby Coors Engineer will be glad to talk to you about ceramic die and bell liners for your sewer pipe machines, or ceramic parts for your other extrusion equipment.

WRITE TODAY FOR COMPLETE INFORMATION

Coors

COORS PORCELAIN COMPANY

600 Ninth Street, Golden, Colorado



Get extra profit from every load

A Bickerstaff Brick Fork gives you extra profit from every load. It's the real "do-it-all" for brick handling. Loads direct from inventory to truck or freight car without rehandling. Cuts labor costs. Speeds deliveries. Reduces breakage. Gives you an extra "profit-bonus" on every load!

Put a Bickerstaff Brick Fork "up-front" on your fork-lift truck. Available in automatic or hydraulic models. Tell us your need - we'll design a fork for the job!

Write today for fully illustrated folder and picture story!

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Brick & Clay
RECORD

October, 1959 Vol. 135. No. 4

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Established 1892.
now in 67th year.

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THE MAGAZINE OF

Brick—Drain Tile—Structural Tile—

Clay Aggregate—Terra Cotta—Roofing Tile

Refractories—Clay Pipe

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Question your AIM*...La Salle Construction Company did...

Steel strapped brick saves builder time and dollars

Acme Idea Man, Phil Raley typifies the packaging experts available to La Salle Construction Company and you.

LA SALLE CONSTRUCTION CO., Chicago, Ill., is saving important materials handling time and labor dollars by requesting that brick be supplied in Acme Steel Strapped packages of 100. (Idea No. S3-17) Three 100-brick packs are lifted by crane to the building floor where they will be used. Then the 100-brick packs are individually delivered by buggy to the exact location desired by the masons.

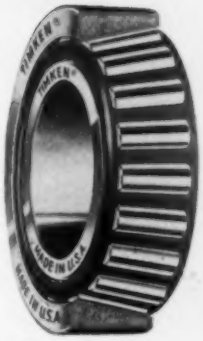
In addition to saving an estimated 20% on brick handling labor, La Salle finds that handling damage, formerly estimated at 5% of the brick shipment, was virtually eliminated. By using packaged brick and a crane, La Salle found that a load of 10,000 brick can be unloaded and delivered to the building floor in about one hour. This compares to a minimum of three hours for two men just to unload the same number of un-strapped brick by hand.

***Question your Acme Idea Man.** His files contain scores of clues to ways your products can be more efficiently packaged. Write Dept. 000-00, Acme Steel Products Division, Acme Steel Company, Chicago 27, Illinois. In Canada, Acme Steel Company of Canada, Ltd., 743 Warden Avenue, Toronto 13, Ontario.

ACME STEEL **STEEL STRAPPING**

TIMKEN TAPERED ROLLER BEARINGS

another reason why Miller Kiln Cars MEASURE-UP to your specifications.



Miller-Built Kiln Cars do the exact job you planned for them to do because they're designed from your specifications to fill your individual needs.

Miller Kiln Cars feature sturdy all welded construction; Timken Tapered Roller Bearings, two units per wheel, plus an exacting design backed up by many years of Miller engineering experience.

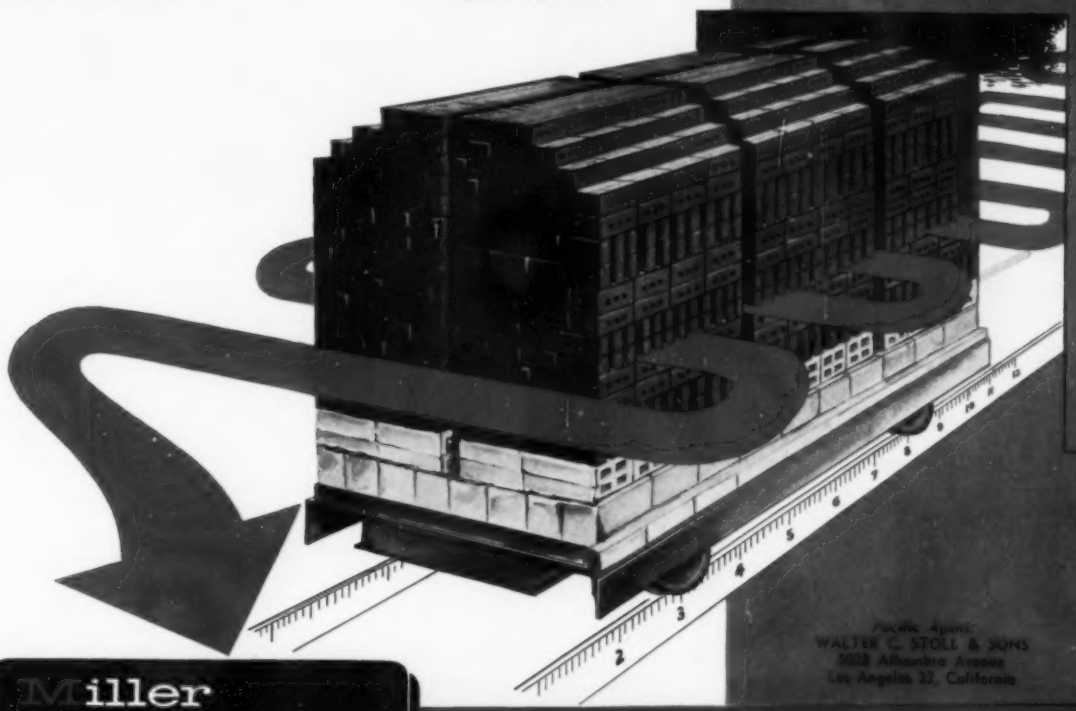
Why not have Miller engineers analyze your Kiln Car and Tunnel Kiln needs. Complete information and prices submitted promptly, without obligation.

LOOK TO MILLER FOR THE FINEST

Cros-Flo Tunnel Kilns • Conveyor Equipment
Hammermill Crushers • Engineering Service

Miller Tunnel Kilns Use CONTROLLED SCIENTIFIC Cooling For High Production

*Patent Applied For



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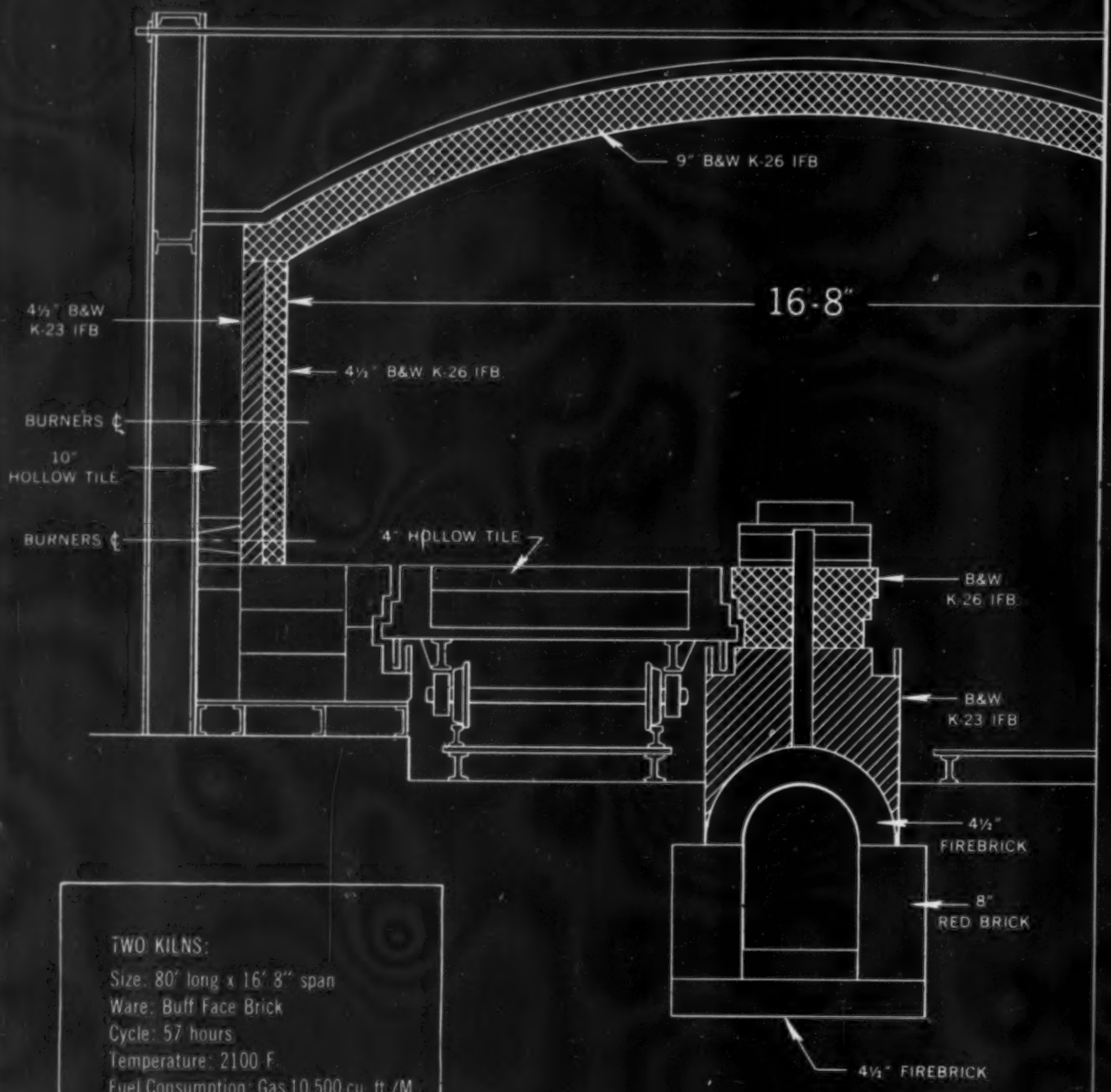
B&W SALUTES SCPI ON 25 YEARS OF PROGRESS

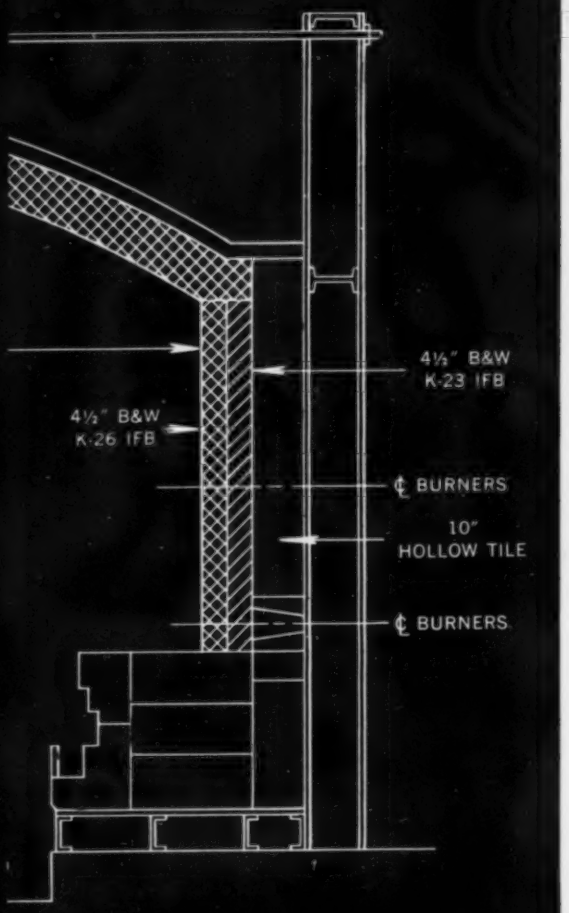


TWO KILNS:
Size: 80' long x 16' 8" span
Ware: Buff Face Brick
Cycle: 57 hours
Temperature: 2100 F
Fuel Consumption: Gas 10,500 cu. ft./M
Lining: B&W K-26 and K-23 IFB

TAYLOR CLAY PRODUCTS COMPANY

reports:

More than 800 burns in shuttle kiln lined with B&W Insulating Firebrick



Two specially designed shuttle kilns lined with B&W Insulating Firebrick were built by Taylor Clay Products Company, Salisbury, North Carolina. This company reports:

The first shuttle kiln has completed 800 burns, and the second kiln over 600. The B&W IFB linings have withstood this long service very well. Product quality has been excellent. Over 99% of the output of these kilns has been grade A brick.

In both continuous and periodic kilns, B&W IFB cut production costs because they are the *lightest weight insulating firebrick made. Lightweight* means low thermal conductivity. In continuous kilns, this low thermal conductivity reduces the amount of heat transmitted through the walls—heat that would be lost to the atmosphere. *Lightweight* B&W IFB keep the heat in the furnace, permitting closer temperature control. *Lightweight* also means low heat storage. In the frequent heating and cooling cycle of periodic kilns, this low heat storage characteristic reduces heat loss because less heat is absorbed by the brick—heat that would be wasted during the cooling cycle. With less heat to dissipate, cycling time can be reduced, too.

In either type kiln, lightweight B&W IFB offer the additional advantages of savings in construction costs and reduced space requirements, both made possible because of thinner and lighter wall and roof constructions.

For more information on the uses of B&W Insulating Firebrick in the structural clay products industry, write for Bulletin R-43 to The Babcock & Wilcox Company, Refractories Division, 161 East 42nd Street, New York 17, N. Y.

B&W

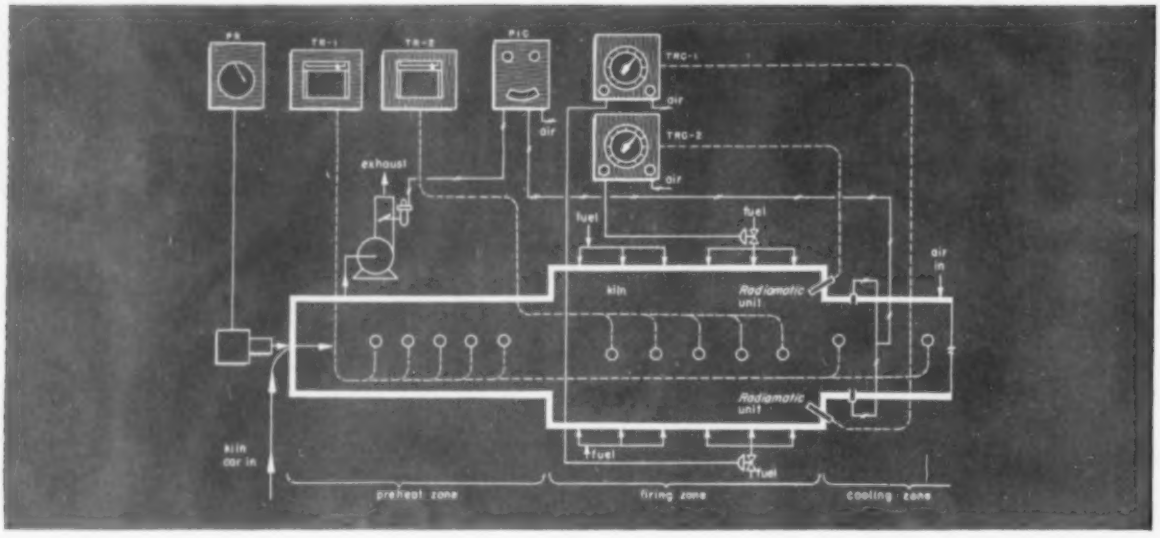
THE BABCOCK & WILCOX COMPANY

REFRACTORIES DIVISION

B&W Firebrick, Insulating Firebrick, and Refractory Castables, Plastics, Ramming Mixes, Mortars, and Ceramic Fiber.

*Electroni*K CIRCULAR CHART PNEUMATIC CONTROLLER with integral bypass control panel—automatically controls fuel input to burners in the kiln firing zone.

Diagram of typical tunnel kiln instrumentation.



Cut firing costs, step up efficiency, increase quality with HONEYWELL TUNNEL KILN CONTROLS

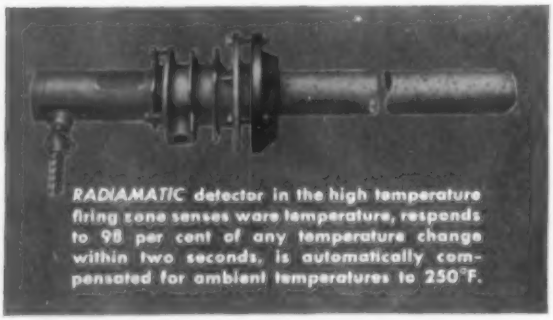
Get uniform firing and better ware with Honeywell tunnel kiln instrumentation. Rejects will be greatly reduced. Fuel and manpower will be employed more efficiently and economically. You will get continuous, profitable production.

Let Honeywell plan a complete, automatic control system, custom-matched to the special requirements of your kiln. You can be sure of top quality throughout, for everything from primary measuring devices to final control elements is made by Honeywell.

Tunnel kiln instrumentation is easily centralized. Instruments can be furnished panel mounted with back-of-panel piping and wiring completed and factory tested, substantially reducing time and cost of installation.

Your nearby Honeywell field engineer can give you complete facts and figures. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

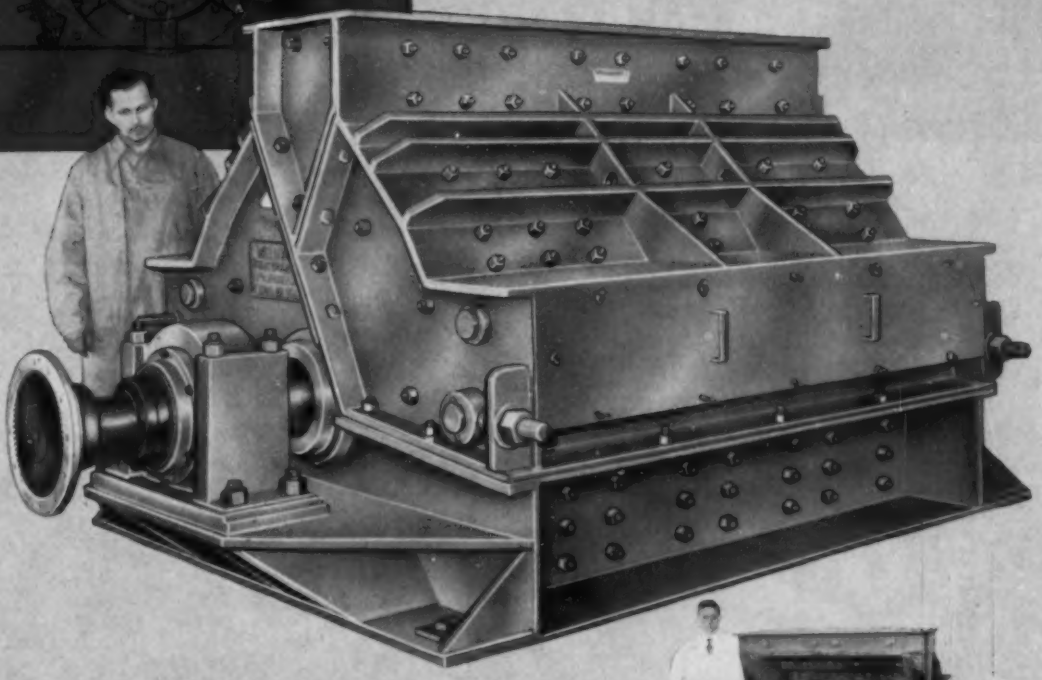


RADIAMATIC detector in the high temperature firing zone senses ware temperature, responds to 98 per cent of any temperature change within two seconds, is automatically compensated for ambient temperatures to 250°F.

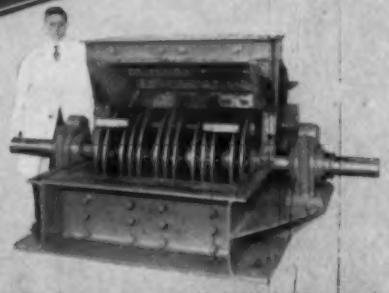
Honeywell

First in Control

WILLIAMS REVERSIBLE IMPACTOR



- 100% Impact Reduction
- No Friction Or Abrasion
- Unobstructed Discharge
- Less Upkeep Expense

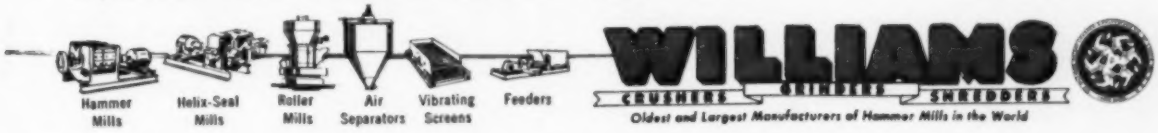


Internal view showing manganese steel impact blocks, hammers and liners. Rugged, heavy steel plate construction. Extra large shafts are mounted in oversize bearings sealed in self-aligning housings.

Lower Cost Crushing And Grinding

Will reduce clay and shale direct from the bank to 8, 10 mesh, or finer, for burned ware. Reduces its own screen tailings. 100% impact action permits reduction of abrasive materials with lower upkeep expense. Material falls *between* the hammers which throw it against the impact blocks, setting up a repeated ricochet action and the reduction is entirely by impact with no wearing, abrasive, grinding action thereby lessening wear on parts. Hammers can be rotated in either direction, rotated to the right today, to the left tomorrow thereby giving double hammer life. Impact blocks adjustable for wear and fineness of product. Finished material is discharged freely which further lessens upkeep expense. A size for every job. Describe your work and let us tell you about one for your use.

WILLIAMS PATENT CRUSHER & PULVERIZER CO.
2709 North Broadway **St. Louis 6, Mo.**

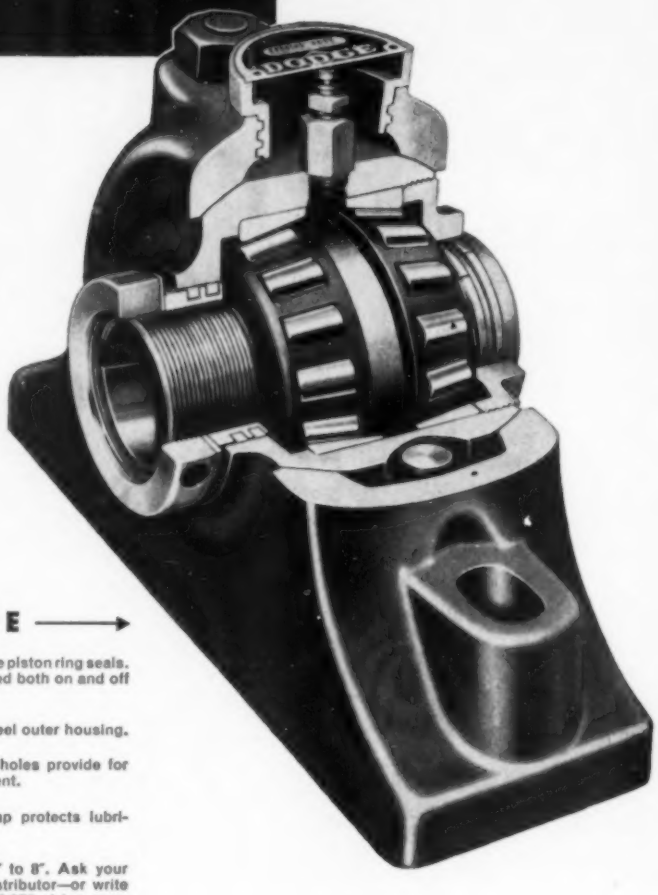


WILLIAMS
CRUSHERS GRINDERS SHREDDERS
Oldest and Largest Manufacturers of Hammer Mills in the World

DODGE PILLOW BLOCKS

WITH TIMKEN BEARINGS

America's super-quality line—with a 35 year record of keeping performance *up* and costs *down!* Five types—to fit practically any service condition. All assembled, adjusted, lubricated and *sealed* at the factory for precision performance—long life—dependability.



SPECIAL DUTY TYPE →

- Designed for extreme precision and high load capacities.
- Fully self-aligning.
- Special Duplex Timken Roller Bearing with tapered bore.
- Split tapered sleeve with straight cylindrical bore extends through entire length of housing.
- Easy to mount or demount. Adapter nut (or collar) clamps adapter sleeve to shaft with extreme firmness.
- Automotive type piston ring seals. Bearing is sealed both on and off the shaft.
- Rugged semisteel outer housing.
- Elongated bolt holes provide for lateral adjustment.
- Special dust cap protects lubrication fitting.
- Shaft sizes 1¾" to 8". Ask your local Dodge Distributor—or write us for Bulletin A670 giving complete technical data on America's most complete line of mounted bearings.

DODGE MANUFACTURING CORPORATION, 4900 Union St., Mishawaka, Ind.

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the *white* pages of your telephone directory for "Dodge Transmissioneer."

DODGE
of Mishawaka, Ind.

HI-DRAFT FANS
A tubeaxial "Hi-Draft" fan for periodic down draft ceramic kilns.

TYPE "J" FAN
Delivers high air volumes at moderate pressures. May be built in a variety of arrangements for different applications.

In our 64th year

ROBINSON *Salutes*

THE STRUCTURAL CLAY PRODUCTS INSTITUTE ON ITS

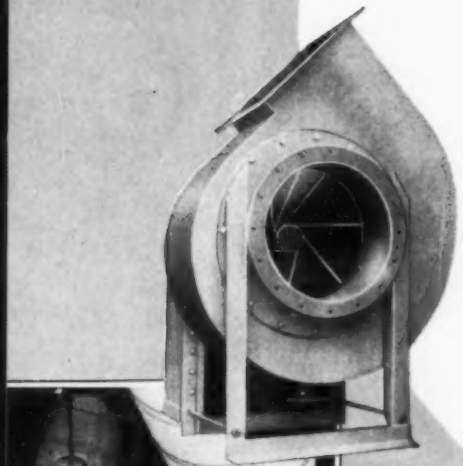
25th Anniversary

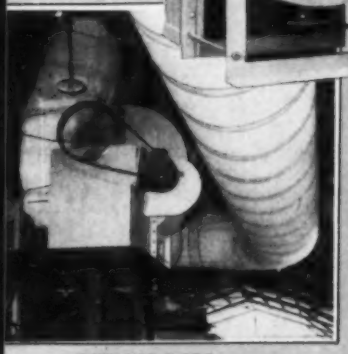
Robinson congratulates the Structural Clay Products Institute on its 25th year of progress and for its many valuable contributions to the ceramics industry.

Manufacturers of air handling equipment for the ceramic industry, we custom-engineer fans, blowers and exhausters to meet the specific requirements of your tunnel kiln, periodic kiln or product dryer. The services of our experienced engineers are available for the design of dryer, ventilation and exhaust systems to fit your particular needs.

Robinson fabricates units to handle a wide variety of applications and supplies a complete range of optional equipment including multi-leaf radial-type inlet and outlet dampers, screens, guards and inspection doors.

For complete information about Robinson products, write for free descriptive bulletins or call your local Robinson representative.





TYPE "AE-6-BB" EXHAUST FAN
Heavy duty exhauster handles air in moderate volumes, at moderate to high pressures. Suitable for many uses.

INDUSTRIAL FANS · BLOWERS · EXHAUSTERS

ROBINSON VENTILATING CO.

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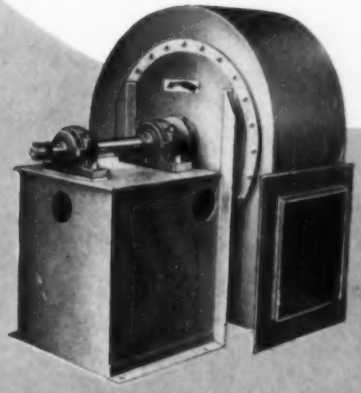


HIGH TEMPERATURE AND DRYER FANS
Designed for recirculating kiln air at temperatures up to 1650° F.

SUSTAINING ASSOCIATE SCPI

Member of AMCA

Improve workability of clay with Additive-A* clay conditioner

It's much easier to handle ware that comes from the extruder when Additive-A is added at the pug mill. And the clay bar flows evenly, is denser, more plastic and better formed with good, square corners. Damage at this stage is lessened. That's why more and more fine brick manufacturers are using this top-grade clay conditioner.

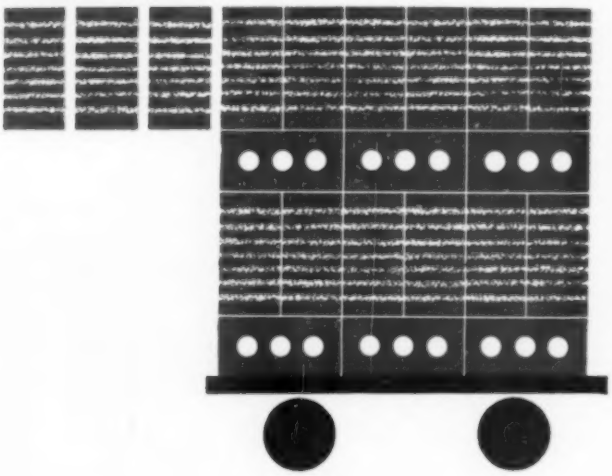
Extra benefits of Additive-A are: Aids water penetration • Cuts dryer loss • Permits more even temper • Controls scumming • Increases dry green strength • Increases green plastic strength • Upgrades the quality of all ware.

Write for descriptive folder, to:

Kimberly-Clark Corporation

NEENAH, WISCONSIN
CHEMICAL PRODUCTS

Additive-A is a trademark of KIMBERLY-CLARK CORP.
*Patented and patents pending.



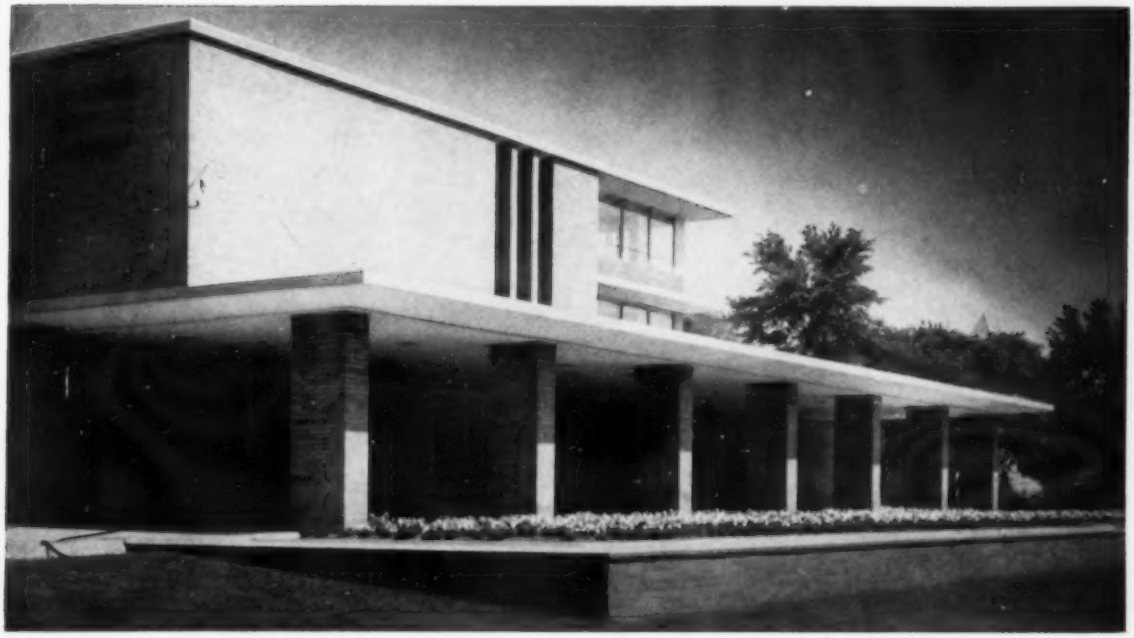
ADDITIVE-A

Contributing Associate of SCPI

Brick & Clay RECORD NEWS REPORT

A complete, compact news section summarizing all developments for the industry's attention.

INDUSTRY NEWS
PRODUCT NEWS
READERS' COMMENTS
PRODUCTION IDEAS



Modern use of brick is illustrated in this photograph. This is the Kresge Science & Wayne Gen. Library. The architect is Suren Pilafian. It is located in Detroit, Mich.

Propose Million Dollar Plant at Durham

A certificate of incorporation for a proposed million dollar brick manufacturing plant in Durham, N. C., has been issued by the North Carolina secretary of state. The charter was issued to Triangle Brick Co., with incorporators James F. Lalanne, Greensboro, N. C., and Thurman H. Holt and Ted W. Tysinger, Pleasant Garden, N. C.

Negotiations are under way over a requested rezoning of the property involved.

Carolina Solite Expanding

Construction of a fifth 135-foot rotary kiln at Carolina Solite's Aquadale, Va., plant has just been completed. This is the third expansion of production facilities at Aquadale since the plant began operations in 1953.

Carolina Solite Corp. is a producer of lightweight aggregates which are produced under controlled process conditions. The aggregates are used in the manufacture of lightweight masonry units and lightweight structural concrete.

Bennett Expansion Will Double Plant

Bennett Brick and Tile, Inc., Kings Mountain, N. C., is planning a $150,000 expansion program which will double the size of the plant and create 20 new jobs. C. T. Bennett, founder of the firm, said he hoped to have the expansion completed by the first of the year.

"The market for our materials has been growing right along," Bennett said. "We're just moving to grow with it." The firm presently employs 40 men.

SCPI To Celebrate Silver Anniversary

The Nationally Famous Greenbrier

Some 1000 people will gather next month at the Greenbrier Hotel in White Sulphur Springs, W. Va. to commerate the silver anniversary of the Structural Clay Products Institute.

In addition to some important business, a fine program

At Greenbrier

of top-flight entertainment is planned as well as full usage of the Greenbrier's excellent recreational facilities. Guests will be entertained by such nation-wide headliners as Herb Shriner, Bonnie Murray, Jacqueline James, Nickie and Noel, and Earl William.

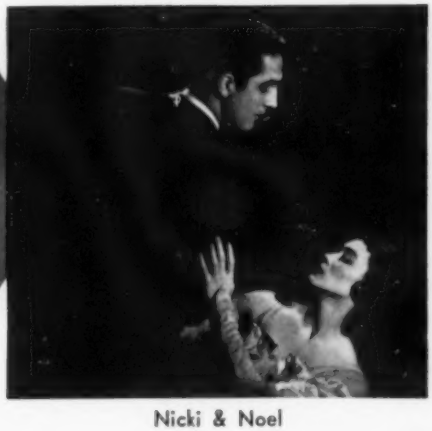
BRICK AND CLAY RECORD in recognition for the many contributions to the industry SCPI has made during the past 25 years is dedicating its November issue to the occasion. B&CR will trace the history of SCPI depicting its development, accomplishments and contributions to our industry, and also illustrating how the record of this organization closely parallels the progress of the industry.

It is expected that there will be about 500 brick manufacturers, dealers and suppliers at the meeting with the remainder of the group made up of wives and children. This affair offers an excellent opportunity for all non-members including suppliers and friends of SCPI to learn first hand

Herb Shriner

Earl William

Bonnie Murray



Nicki & Noel

not only of SCPI's past but perhaps even more important, just what lies ahead in the future.

By the time that this convention is adjourned the new year will be only a few weeks away. With the advent of the scintillating, soaring, sensational, superlative '60s, the clay products industry is willing, eager and anxious to determine just what part it will play in this tremendous growth era.

Many questions and challenges will be taken up at the affair. Such problems as future markets, just what's going to happen in the industry, and even if competition is strong enough to replace structural clay products, will come in for discussion.

SCPI has grown up and now that it is firmly established is eagerly looking ahead. Members and non-members alike are pondering the always uncertain future and attendance at this meeting might help to point you in the right direction.

The 25th Anniversary brings out two very important facts. First, this is the only organization in the clay products industry with a 25-year record behind it. From its auspicious record it appears that it has many years ahead of it. Secondly, its membership which is always an organization's backbone is a cross section of men who have been with SCPI since its inception as well as the many members who have joined SCPI down through the years. This solid foundation made up of a wide difference in ages, assures an excellent exchange of ideas plus a sound nucleus for future growth.

It is hoped that anyone connected with the brick and tile industry will take advantage of this meeting so that he may learn more about SCPI and so that SCPI itself may benefit from meeting him.

A Look at The Latest in Industry News

American Marietta Co. Sets Sales Record

The highest sales and earnings for any third quarter and nine months in its 46-year history were reported in September by American-Marietta Co. Net income of $17,232,130 for the nine months ended August 31, 1959, which nearly equalled net income for the entire 1958 fiscal year, rose 53% above the $11,229,323 earned in the 1958 nine months.

Sales of $234,954,020 for the 1959 nine months increased 33% over sales of $176,343,663 for the three quarters of 1958.

Expert Reports On Beneficiation Method

Beneficiation—a time-honored method for separating minerals from less valuable components of the earth—could be equally useful in many industries far removed from the production of minerals. So say Adam L. Wesner, specialist in beneficiation research at Battelle Memorial Institute, Columbus, Ohio.

In an article in the *Battelle Technical Review*, Wesner lists 28 unusual applications for beneficiation techniques that are in limited use or are feasible. These applications range from the separation of sewage from water by a flotation process to the separation of weeds from seed by electrostatic separation.

W. S. Dickey Co. to Double St. Louis Production

A major expansion program now under way will double production at the St. Louis plant of the W. S. Dickey Clay Mfg. Co. The program has been undertaken to keep pace with the growing demand for clay products in the booming Missouri and Illinois markets.

Plans call for a 470-foot Swindell-Dressler straight line tunnel kiln. In addition, new horizontal extrusion machines will be added to those now in use. Total cost of the entire program will exceed $800,000.

When completed, the new addition at St. Louis will increase production by over 30,000 tons annually. New buildings and equipment are scheduled for use early in 1960. Equipment will be installed to permit the manufacture of longer lengths of clay pipe, including 8", 10", and 12" in 5-foot lengths. At that time only extra strength pipe will be manufactured on 10" and 12" pipe and the standard strength line dropped on these sizes.

SCPI Official Reports to Housing Conference

"Brick and tile manufacturers know all of the technical answers about their product, but they are constantly searching for new ways to give consumers what they want in a home," John E. Clark, director of promotion for the Structural Clay Products Institute, told the recent Family Conference on Housing in Washington.

For example, he said, brick manufacturers have noted a strong trend in recent years toward the use of exposed brick wall interiors in the living room, kitchen and family room. SCPI is very interested in learning if there are other areas in the home where this type of wall is desirable.

Clark also asked members of the Conference if they were interested in spending small amounts of additional money to have bomb and natural disaster shelters built adjacent to homes.

Jenkins Brick Co. Completes New Plant

Jenkins Brick Co. has completed a brick manufacturing plant at Coosada Station, Ala. The plant, situated on a 40-acre tract of land, represents an investment "in excess of $1 million," according to John S. Hodgson, chairman of the board of directors.

The plant will boost Jenkins Brick's production by 50% and adds 35 employees to the 130 already on the payroll at the original Montgomery, Ala., plant. The plant has a minimum capacity of 1.5 million brick per month and features automation throughout. The firm contemplates the addition of another kiln as the next step in its expansion, and $60,000 was spent in the original designing to incorporate plans for a second kiln.

Southwestern Expands

Southwestern Brick & Tile Co., Snyder, Texas, has improved its operation with new kiln and clay storage buildings, and is building a new shuttle kiln. The firm has also just installed a J. C. Steele 40F brick machine and is planning a primary roll crusher.

Search Canada for Clay; Hope to Reduce Imports

Clay is the target of a new search getting under way in Ontario's northern sedimentary belt around James Bay. Partners in the probe are American Nepheline and its parent, Ventures Ltd.

Canada's annual $5.3 million import bill for special clays and silica sands has sparked the search, as American Nepheline steps out to diversify its industrial mineral operation near Peterborough, Ont.

Prime target of the exploration is kaolin, of which there is no commercial production in Canada.

Hiram Swank Hosts Foreign Trainees

Eighteen Latin American industry trainees were recent guests of Hiram Swank's Sons, Woodvale, Pa. The visitors got a first-hand look at the manufacture of some of the fireclay refractories—sleeves, nozzles, runner brick, etc.—they will be using as they pursue their careers in the future.

Albert M. Swank, president and board chairman of the local company, personally conducted the tour. The trainees come from six different countries, including Argentina, Brazil, Chile, Colombia, Mexico and Peru. All are being sponsored on a year-long stay in the U.S. by the Pan-American Union in cooperation with individual employer companies.

Florida Georgia Brick Appoints Two

Florida Georgia Brick and Tile Co., Jacksonville, Fla., has announced the appointment of B. R. Sonnenfield as office manager and Wayne C. Schelldorf as manager of architectural promotion and sales.

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COLOR—By facing your common brick with Drakenfeld glazes you can get premium prices. Drakenfeld will help solve your color application problems. B. F. Drakenfeld & Co., Inc.

21/Circle on Reader's Service Coupon

SCREEN HEATERS—Heated screens can eliminate blinding, increase tonnage, build greater profits and speed your production. F. R. Hannon & Sons.

22/Circle on Reader's Service Coupon

PLASTI-KING GLOVES—Has seamless wing thumb, tough but fully flexible. Gloves are infra-red cured for greater resistance. Sarjanian Glove Co.

23/Circle on Reader's Service Coupon

ROCKFACERS—Can turn a loss into a profit by making 2,000 culls per hour into a premium rock-faced brick. One owner says that his machine was paid for 3 times in the first 9 months. Rockfacer Co.

24/Circle on Reader's Service Coupon

HOW TO USE:

All you do is circle the number of the editorial item or the page number of the advertisement on this card, and mail it to us.

GLOVES—Gloves, hand pads and mittens protect workers hands, are flexible and comfortable to wear, made of finest cowhide. Des Moines Glove & Mfg. Co.

25/Circle on Reader's Service Coupon

TAM—Lot after lot, Tam is consistently uniform opacifier. Complete line includes Superpax A, Superpax, Opax, Opax S, Treopax, Zircopax, and double silicates. Titanium Alloy Mfg. Co.

26/Circle on Reader's Service Coupon

10-59

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8 Allis Chalmers Mfg.
9 Kol, Inc.
10 Babcock & Wilcox
11 B-I-F Industries
12 Kwik-Mix Co.
13 Porter, H. K.
14 National Engineering Co.
15 Wilson Rubber Co.
16 Pemco Corp.
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21 Drakenfeld, B. F. & Co.
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31 National Sewer Pipe Ltd.
32 Kinberly-Clark Corp.
33 Stoody Co.
34 Hommel, O. Co.
35 American Clay Machinery Co.
36 Fate-Root-Heath Co.
37 Buffalo Forge Co.
38 Bradney Machine Co.
39 Engineering Associates, Inc.
40 Swiss Fabricating Co.
41 Swindell-Dressler Corp.
42 Link-Belt Co.
43 Acme Steel Co.
44 Deister Concentrator Co.
45 Bonnot Co.
46 Orton, Edw. Jr.
47 International Clay Machinery
48 Superior Supply Service
49 Robeson Process Co.
50 Tyler, W. S. & Co.
51 Williams Patent Crusher & Pulv.
52 Thayer Scale Corp.
53 Stanley Steel Strapping Co.
Page 2 Bonnot Co.
Page 3 Coors Porcelain Co.
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Page 8-9 Babcock & Wilcox Co.
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Page 23 Pemco Corp.
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Page 94 American Clay Machinery

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This card void after December 30, 1959

PACK-HAULERS—Can increase your profits by cutting per-thousand delivery costs, allowing use of smaller fleets, savings on insurance, upkeep and licenses. Split load deliveries can be made. American Truck & Body Co.

27/Circle on Reader's Service Coupon

VARCO BUILDINGS—Payne Brick Co., of Elgin, Tex., chose Varco to build their clay storage building because of low cost and fast erection. Building in 60, 80 or 100' clear spans; can handle any type conveyor system up to a 24" belt; buildings are sturdy, with very low maintenance. R. G. Varner Steel Products Inc.

28/Circle on Reader's Service Coupon

CONVEYOR BELTING—Scandura has new fire-proof belts that eliminate fire hazards, will not strip or tear. Belt absorbs terrific impact with minimum abrasion, maker says. Scandinavia Belting Co.

29/Circle on Reader's Service Coupon

DRILLING—Fast drilling with heavy duty, four speed auger, finger tip control, 65 hp motor, all drives mounted on Timken Roller bearings; three leveling jacks to insure straight holes. Paris Mfg. Co.

30/Circle on Reader's Service Coupon

PIPE JOINTS—Plain End Couplings are available to pipe manufacturers on a royalty basis, in diameters from 4" to 24". Fittings assemble easily, are flexible, hold pipe in compression, not under tension. National Sewer Pipe Ltd.

31/Circle on Reader's Service Coupon

ADDITIVE-A—Use of Additive-A allows tempering water to penetrate more easily, requiring less water. Other advantages reported are increased green strength, improved clay workability, reduced dryer losses. Kimberly-Clark Corp.

32/Circle on Reader's Service Coupon

TUBE BORIUM—Stoody's tube borium uses relatively coarse, ready-made tungsten carbide particles, rather than microscopic metallic carbides. What this means is that you can get one of the hardest, most abrasion resistant metals known for your hard surfacing work. Available in mesh sizes from 5-8 to 40 down. Stoody Co.

33/Circle on Reader's Service Coupon

FRITS AND STAINS—Hommel has the frits and stains you need for glazed brick or tile. Glaze frits and body, engobe and glaze stains are made to meet all requirements. O. Hommel Co.

34/Circle on Reader's Service Coupon

GRINDERS—America's 384 grinder has been designed to handle big volume grinding at a rate of a ton a minute, handling hard clay shale and other material. Materials can be handled wet or dry because there are no screen plates to clog. American Clay Machinery Co.

35/Circle on Reader's Service Coupon

EXTRUSION—Marion Brick uses an F-R-H de-airing extrusion machine to get close quality control. Their F-R-H is said to provide extra hard, uniform columns that help maintain production schedules. Fate-Root-Heath Co.

36/Circle on Reader's Service Coupon

FANS—Buffalo Forge CR radial blade fans are built sturdy to work under tough conditions. Use of a refinement of the radial blade design gives both boosted performance and reduced wear. Buffalo Forge Co.

37/Circle on Reader's Service Coupon

TRUCK CRANE—Can unload off either side, put loads on the sidewalk; handles brick or block unpalleted or palloted or packaged. Bradney Machine Co.

38/Circle on Reader's Service Coupon

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Gen. Refractories Reports On Financial Status

General Refractories Co.'s earnings for the first seven months of this year were equal to $1.98 a common share, indicating a loss for July, but still more than double the net in the like 1958 months.

The company previously reported net income of $2,922,469, or $2.09 a share, for the first six months of this year and a net of $1.98 a share for the seven months would indicate a loss of nearly $200,000 in July. Sales for the 7-month period were $38,000,000, company officials said, against $24,700,000 in the first seven months of 1958.

Report on 1957 Fiber Pipe Survey

Production of bituminized fiber sewer and drain pipe by the nation's eight manufacturers, operating 11 plants, aggregated 75,680,000 lineal feet in 1957, according to a survey recently conducted by the Building Materials Division of the Business and Defense Services Administration. Some 67,596,000 lineal feet of this production was 4-inch pipe.

In addition, the survey indicated that during 1957 the industry produced 12,202,000 fittings, 10,000,000 of which were couplings. The balance of the fittings are also generally used in connection with the installation of bituminized fiber pipe. The production figures stated do not include fiber pipe conduits which are also produced in the same plants but which have thin walls.

Mason Contractors Review Current Problems

Increasing popularity of masonry in northwest residential and commercial construction was underscored at the recent meeting of the Northwestern conference, Mason Contractors Association of America, held in Portland, Ore., Sept. 12.

Mason contractors discussed the current survey being made by the Unit Masonry Association on the effects of a recent explosion at Roseburg, Ore., on masonry construction. The blast of a dynamite-laden truck severely damaged the main business section of the community.

The conference resolved to put forth as a conference objective the trade discount program now in effect in Seattle. A continuing study will be made of the Seattle system.

Other discussions centered on availability and distribution of materials, industry ethics, upgrading of work performances and advantages of MCAA affiliation to nonmember contractors.

Elected officers (l-r) include C. L. Gerring, V.P.; L. C. Pardue, Pres.; Lloyd Beck sec.-treas.

Porter Completes New Plant At Pascagoula, Miss.

H. K. Porter & Co., Inc. recently completed a $12 million plant at Pascagoula, Miss. for the production of magnesia from sea water and basic refractories. Installation late this summer of a metal casing machine, which steel clads basic refractory brick was the last item needed to complete construction. Clad refractory brick are used extensively in metalworking furnaces, as well as by the glass industries.

Reportedly one of the most modern brickmaking operations in the country, the new plant using magnesia produced at the sea water plant, manufactures chrome-magnesite, magnesite-chrome and periclase type basic brick in burned, unburned and steel-cased bodies. In addition, a line of chrome and periclase specialties is produced.

The Pascagoula works is said to be a completely integrated facility for the production of basic refractories. The sea water chemical plant produces 125 tons per day of high-purity, dead-burned periclase and the basic brick plant converts the periclase and chrome into basic refractories, both brick and specialties.

The new plant utilizes modern refractory brick-making equipment while improved methods have been developed for grinding, batching and pressing brick. Controlled sized fractions are stored in 60 bins which supply both the brick-making and specialty operations. Batching is highly automated and controlled by one man for the entire plant. All electrical and electronic controls for the batching system are housed and operated from a central room. Newly designed-heavy-duty presses are used for the brick production.

Porter's total property value here is over 400 acres with the plantsite proper consisting of approximately 45 acres. The building and equipment structures rest on some 7950 piles of fill ranging from 60-90 ft. in length. The L-shaped dock is 566 ft. long by 50 ft. wide.

Noted Librarian Retires

Emily VanSchoick is retiring as librarian of the State University of New York, College of Ceramics at Alfred University. After retirement, Miss VanShoick will devote her time to correlating definitions of words in special usage by members of various divisions of the ACS.

Raze Boston's Oldest Brick Structure

Boston's oldest brick building is being razed to provide the site for a new $27 million federal office structure.

Known as the Old Corner Bookstore building, it has stood at Washington and School streets in downtown Boston since 1712. During the 19th Century it was the literary center of Boston, frequented by Longfellow, Whittier, Hawthorne and others.

Name Don Smith Ironton Plant Head

Donald R. Smith has been promoted to the position of plant manager of the Ironton Fire Brick Co., Ironton, Ohio. His duties will be the operation of the plant in Ironton and the mines at Soldier (Olive Hill District), Ky. Smith, a ceramic engineer, was formerly manager of the special products division.

ABC Invaluable Aid In Publishing Field

Perhaps you, too, have noticed a growing tendency on the part of many people to accept almost anything as the truth.

In fact, it's probably a testimonial to man's faith in his fellow man that the only people whose facts are generally under suspicion are those who fish (for fun or conversation).

Sad, but true, there are a lot of advertising salesmen about these days with "facts and figures" that have about as much logic (and fiction) as the story the fellow told of having caught an 8-pound bass with a piece of store string and a bent nail.

When you buy advertising—no matter how much you spend—you have every right to know exactly where that advertising is going to be circulated, whether the medium actually provides an audience of interested readers, and how large an audience your message will have.

Don't trust your business to fish stories. Make sure the advertising medium you use is qualified to display the symbol as a member of the Audit Bureau of Circulations.

This magazine is an ABC member. Ask to see a copy of our latest ABC report containing complete, verified facts about our circulation.

Clifford L. Meanor Dies at 66

Clifford L. Meanor, 66, president of the Clay Flue Lining Institute, died September 28 at the age of 66. Mr. Meanor, widely known in the clay industry, helped found CFLI and had been associated with CFLI since its organization in 1954. Prior to joining CFLI, Mr. Mesnor spent almost 50 years with Natco Corp., Pittsburgh.

$2.5 Million Improvements At Hanley Plant

The Hanley Co., Summerville, Pa., has made major improvements on two tunnel kilns and two driers, and has installed a new auger and four new pug mills, among other equipment. The total over-all cost of the improvements is set at $2,500,000; numerous changes will be made in manufacturing methods.

Danes Visit Kaul; Firm Launches Scholarships

Two Danish businessmen were recent visitors at the Kaul Clay Co., Toronto, Ohio. They were Jens Ib Thage and Carl Veldemar Kahler, who are representatives of Hasle Klinkerog-Charmottestenfabrik. They are studying marketing and production.

Kaul has also announced the establishment of a scholarship in the Department of Ceramic Engineering at Ohio State University. The first recipient is John M. Saner, of Toronto. Saner was employed in the Kaul laboratory during the summer vacation and is now at Ohio State.

May Build Brick Plant

The natural clay deposits of Yazoo County, Mississippi, may attract a brick plant to the area, according to a report made last month to the Yazoo County Industrial Development Corporation.

The clay deposits are located south of Yazoo City on the property owned by E. W. Cooper. Two types of clay are available, making a choice of brick color. The plant, to employ about 50 people, would include a 400-ft. kiln and could make about 60,000 brick a day.

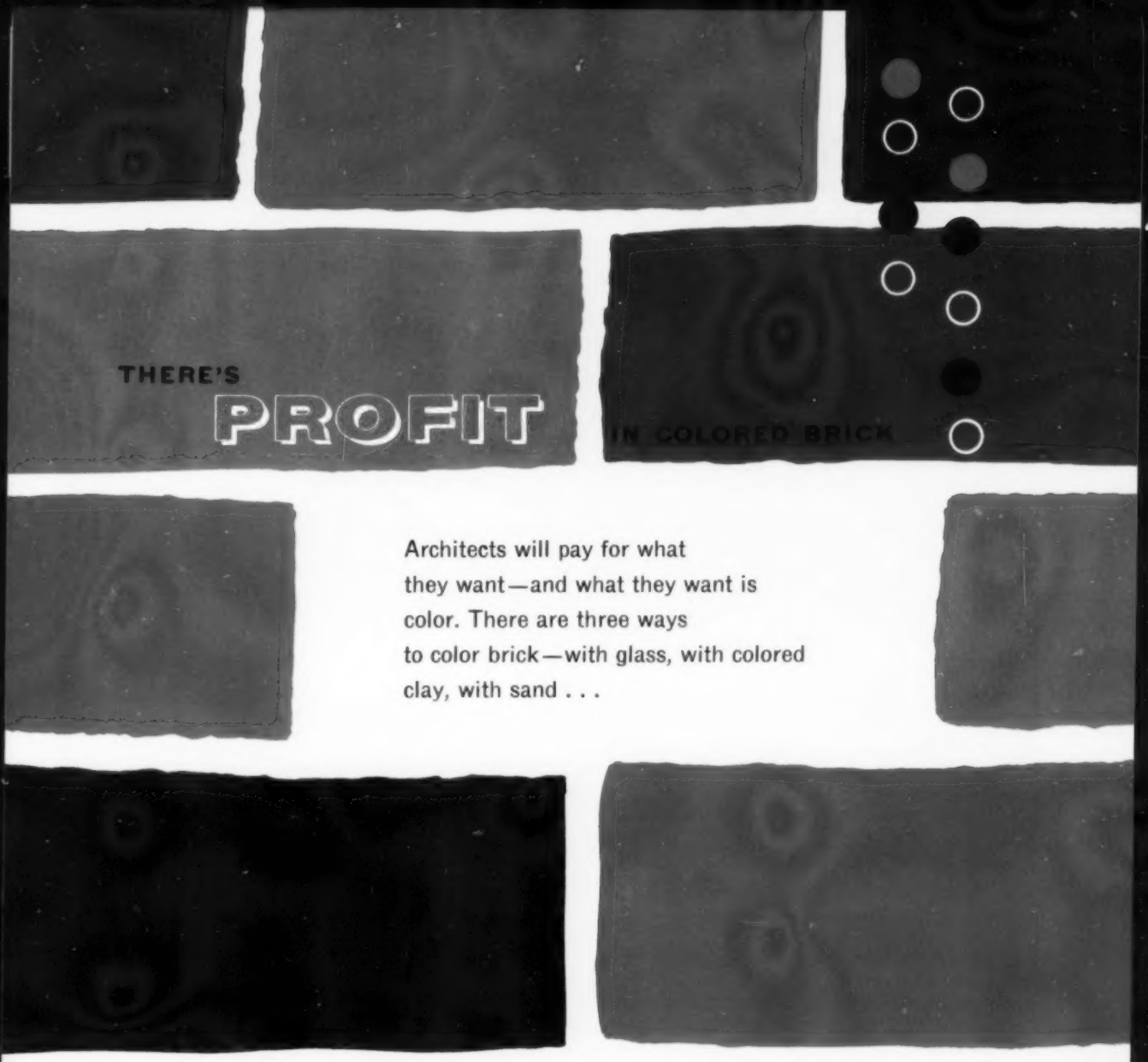
Robinson Clay Starts Huge Expansion Program

The construction of six new 44-ft. periodic kilns spearheading a $750,000 expansion program at Factory No. 8 in Pottstown, Pa. An important part of Robinson's Wedge-Lock Clay Joint Clay Pipe production is concentrated at Pottstown.

Completion of the periodic kilns and other plant changes incurring an additional dryer will augment production capacity of the Pottstown plant by one-third. The overall program also contemplates improvements and expansion of processing, drying and firing facilities. Plans also call for the addition of a mobile equipment repair shop and extensive rebuilding of access roads and yard facilities.

Swindell-Dressler Corp. Acquired by Pullman, Inc.

The 110-year old Swindell-Dressler Corp. of Pittsburgh has been acquired by Pullman, Inc. The announcement was made recently. It was also learned that the Swindell-Dressler Corp. will remain at its present location in Aspinwall, Pa. and will carry on with the same officers and personnel. Wm. H. Cosgrove will remain as Board Chairman and Harold I. Martin stays as president.



Architects will pay for what they want—and what they want is color. There are three ways to color brick—with glass, with colored clay, with sand . . .

GLASS.
A ceramic glaze gives brick sparkling, brilliant color that gleams like jewels. Pemco will develop a ceramic glaze formula for your brick. Send pieces of fired and greenware.

CLAY.
Engobes coat bricks with velvety, matt-finish pastels. This is beauty that is new for brick—vastly desirable and very saleable. Send for a sample of dry engobe, ready to use. Just add water and spray on green brick.

SAND.
These coatings give brick a weathered look that architects admire. To make the sand adhere, or to improve the color, write to Pemco about Bricwite—with or without colored stain added.

RESEARCH AND A FLAME

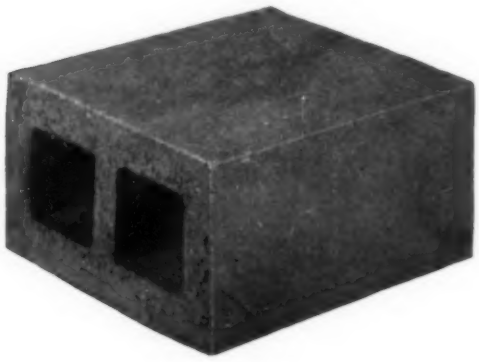
PEMCO

Ceramic frits, inorganic pigments, vitrifiable glass colors BALTIMORE 24, MARYLAND

Photo shows PACO 4½" x 8" x 9" car tops set on end and used as perimeter block. Top deck is constructed with 4½" x 8½" x 18" PACO car tops. Each corner has a 7" x 8½" x 9" cored corner block. Perimeter and corner blocks are filled with lightweight insulation.

PACO CAR TOPS can cut your replacement costs as much as 50% — and increase your profits! The reason is simple. Paco Car Tops are made from the mineral pyrophyllite. This unusual, superior raw material permits the manufacture of thinner wall, larger core car top that is lightweight, stronger and highly resistant to extreme thermal shock.

PACO CAR TOPS do not have a softening point below actual fusing point, providing greater resistance to hot load deformation. The result is better, more efficient production. Paco Car Tops are easy to handle and install, and simple to replace individually as needed.
There is a PACO engineer as close as your telephone—or write for complete information!



SEE OUR CATALOG IN
Ceramic data book

NORTH STATE PYROPHYLLITE COMPANY, INC.

Telephone CYpress 9-1441 **Greensboro, North Carolina**

OTHER PACO PRODUCTS INCLUDE: • Paco Plastic • Pacocast • Paco H.T. Cements • Paco Fire Brick Mortar • Paco Side Car Brick • Paco Fire Brick • Paco Ladle Lining • Paco Heatzone Compound

New Products

Pistol Grip Sealer

The new Model RCNS pneumatic sealer features a pistol grip for convenient sealing of ¾-inch steel strapping with one hand. The unit weighs six pounds. To operate, you set the tool on the seal and pull the trigger; compressed air does the work. The sealer is available on an annual rental or single payment basis.

Signode Steel Strapping Co.

1/Circle on Reader's Service Coupon

Rubber Patching Material

A new abrasion resistant, adhesive rubber sheeting for covering of chutes and launders or patching of conveyor belt surfaces has been announced. Known as "Armorline," the material can be applied to metal, concrete, wood and other materials almost as easily as a cold patch to an inner tube. A thin gauge of tacky rubber is bonded to the bottom side of the material, protected by Holland cloth which is removed before use. Neither expensive tools nor special skill are required for covering or patching equipment in the field.

B. F. Goodrich Industrial Products Co.

2/Circle on Reader's Service Coupon

Fastermatic

Item has a six station turret for turning, boring and facing of miller kiln car wheel units. On this machine kiln car wheel castings are completely machined in one setting to precision tolerances for Timken bearing assemblies. Is said to furnish kiln car customers with the most modern automation to produce superior units.

Miller Equipment Co.

3/Circle on Reader's Service Coupon

Forks and Truck Crane

Savings and time are affected through the use of these forks and truck cranes. These forks are reported to be able to handle up to 2,000 brick and more (if wanted) at a time. Two kinds of forks are made; one for use on lift trucks—to set and draw from closed or beehive kilns or on kiln cars and for storage anywhere. The other—the crane fork for use on cranes are more flexible in removing from or setting on kiln cars, or from dryer cars to kiln cars. The Priester truck crane loaded by either type of above forks or by itself, saves handling time. After the unit is once made up at the belt it needs never to be dismantled until taken to job site and the brick put in the wall.

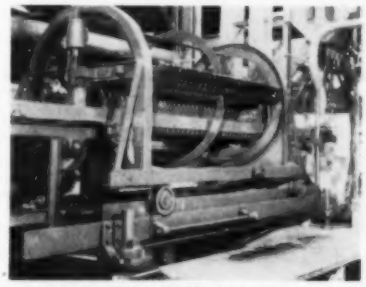
Bradney Machine Co., Inc.

4/Circle on Reader's Service Coupon

Improved Brick Cutter

A specially made #30 Series cutter is designed to make 30 brick per cut, with a capacity of up to 30,000 per hour. The machine is a refinement of one model within the currently manufactured #30 Series. Production rates up to 25,000 per hour have been attained as and when required since 1954. The machine is designed to meet future needs of the structural clay products industry.

Chambers Brothers Co.



5/Circle on Reader's Service Coupon

High Temp Lubrication

An answer to the problem of lubrication at high temperatures is Almasol #1250, which is disposed to remain chemically stable up to 1900° F. It is said to provide lubrication and protection never before possible for roller bearings in kiln cars and other subjects exposed to the heat. The material is similarly impervious to acid.

Lubrication Engineers, Inc.

6/Circle on Reader's Service Coupon

Front End Loader

A new front-end wheel loader, the TL-20 TractoLoader, incorporates an exclusive single-lever speed and direction control for more rapid operation. The operator can choose any of six speed and direction combinations by operating one lever. An automatic clutch cutoff delivers full engine power to the hydraulic system at a touch of the brakes. Six buckets are available for use with this model, in sizes ranging from 2¼ to 5 cu. yd.

Allis-Chalmers Mfg. Co.

7/Circle on Reader's Service Coupon

Air Heating Burner

A new Airflo gas burner system provides flexibility of temperature and loads in industrial air heating applications. The Airflo may be used on either recirculating or single-flow systems. In addition to its use in kilns and dryers, the system is suited to heating the make-up air introduced into plants to replace that exhausted from spray booths, hoods, etc., through fans and stacks.

Maxon Premix Burner Co.

8/Circle on Reader's Service Coupon

All-Purpose Mixer

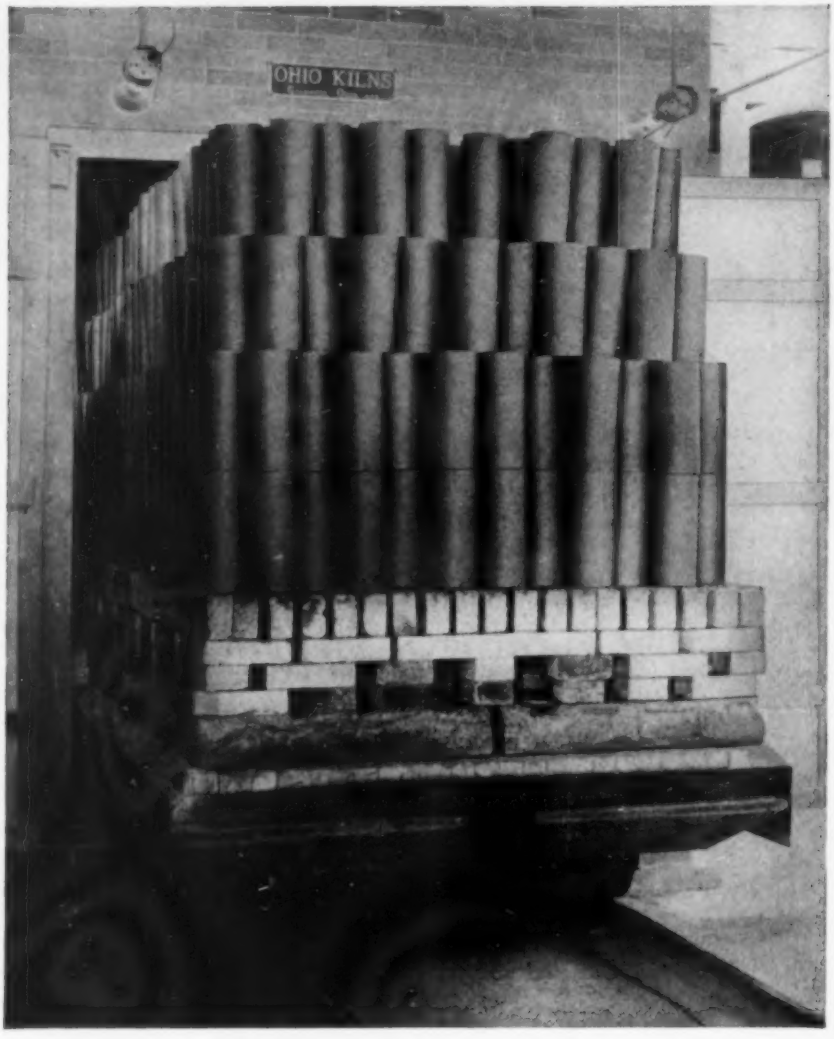
Here is a mixer said to mix everything from coarse aggregate concrete to thin slurry mixes. The Mixal mixer allows the operator to select and set any of four mixing angles for every type of mixing job with just a touch of the toe. The device features a tilting, removable mixing pail and paddle. The pail can be adjusted to four angular positions to produce a wide range of agitation for any mixable material.

Kol, Inc.

9/Circle on Reader's Service Coupon

Continued on page 50

Refractory concrete car tops last longer



At Orville Tile Company (Orville, Ohio), car tops are cast in place with refractory concrete made with Lumnite calcium-aluminate cement and suitable aggregates. Such car tops will withstand high heat and retard the flow of heat down to the steel framework of the car. Refractory concrete tops offer high resistance to thermal shock. Spalling and cracking are minimized. And they are easy and economical to install, using plant labor and equipment. Concrete will reach service strength in 24 hours.

For added convenience, there are castables bonded with Lumnite cement. These are packaged mixtures, ready for use with the addition of water. Just mix and place. They are available from leading manufacturers of refractories. For additional information, write Universal Atlas Cement, 100 Park Avenue, New York 17, N. Y.

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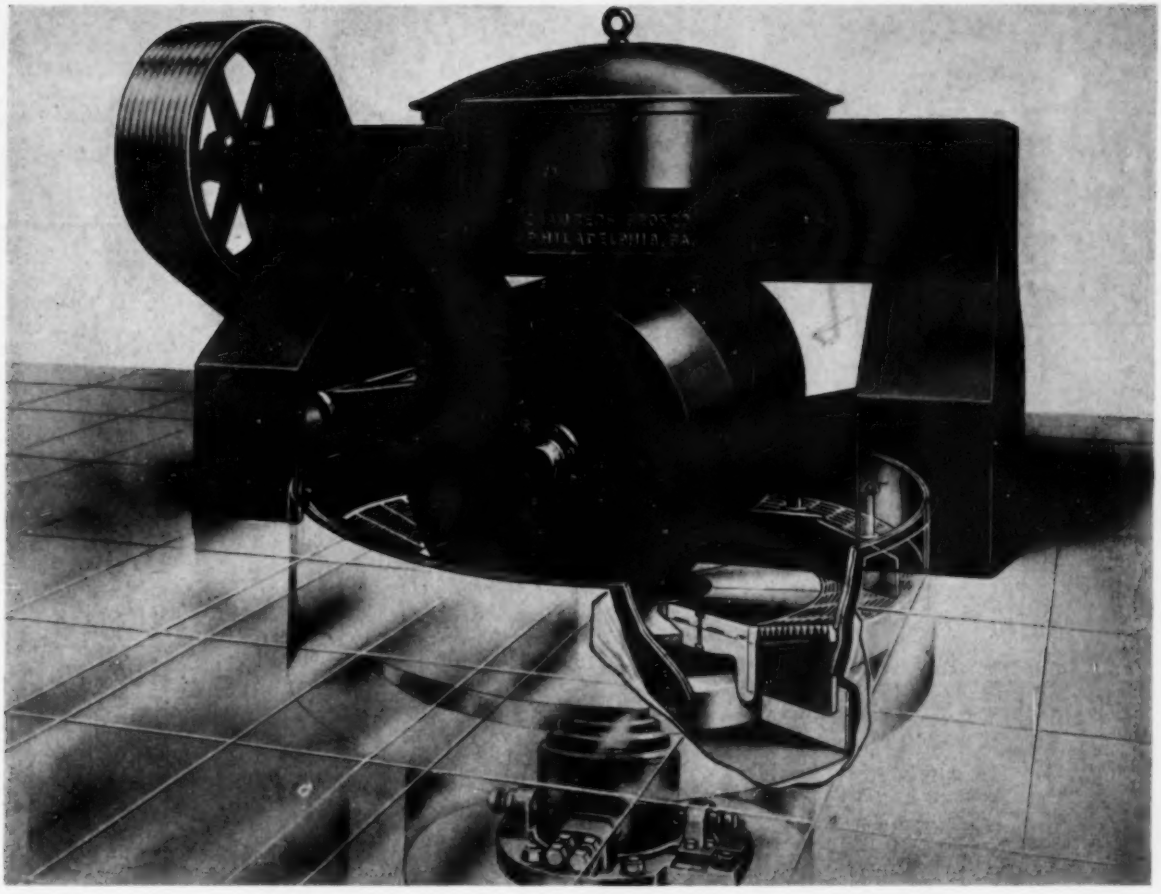

The Chambers-International 10' Dry Pan is a massive 80,000 pounds' worth of grinding efficiency, with two oversize mullers 18" in face by 60" in diameter. As the inclined screen plates slow up the clay's centrifugal movement, more to grind is continually fed where it can be ground best. This is a dry pan ideal for hard and medium-hard materials used in structural clay product and refractory manufacture.

Chambers, long well known for dry pans, is proud to offer the Chambers-International, incorporating the tried and tested design with Chambers workmanship, and for the future, design and development for constant improvement.

The Chambers-International 10' Dry Pan has heavy welded-steel side frames, upper crosshead, and muller arms—for a lifetime of service. All bearings are anti-friction roller, with SKF self-aligning roller thrust bearings in step—for trouble-free, long-lasting performance. Complete dust enclosures are supplied to order. Write or call for further information, without obligation.

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CHAMBERS INTERNATIONAL

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10' DRY PAN

SERVING YOUR INDUSTRY FOR OVER 100 YEARS

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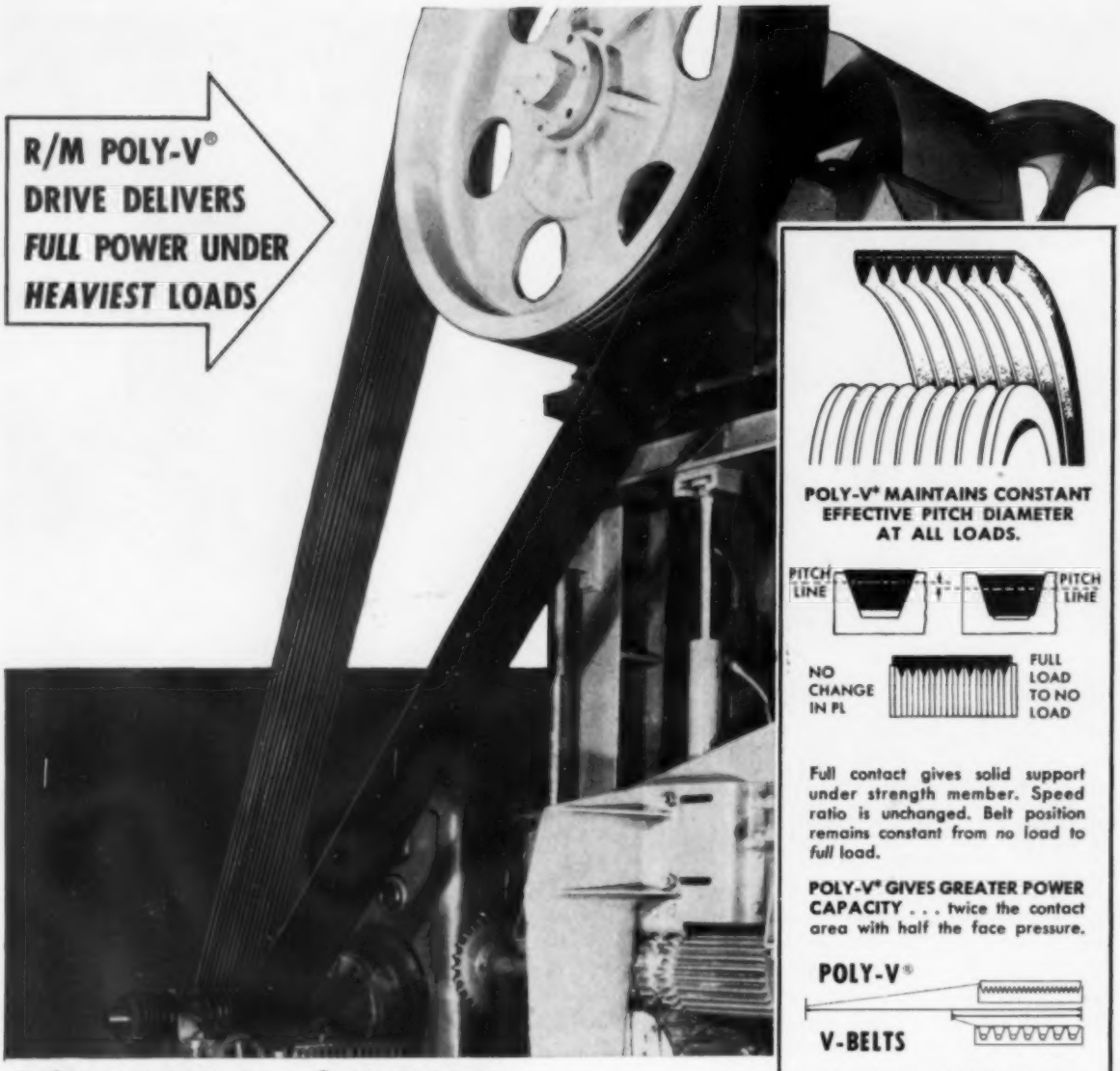
R/M POLY-V®
DRIVE DELIVERS
FULL POWER UNDER
HEAVIEST LOADS



POLY-V® MAINTAINS CONSTANT EFFECTIVE PITCH DIAMETER AT ALL LOADS.

Full contact gives solid support under strength member. Speed ratio is unchanged. Belt position remains constant from *no* load to *full* load.

POLY-V® GIVES GREATER POWER CAPACITY . . . twice the contact area with half the face pressure.

POLY-V ELIMINATES V-BELT MATCHING PROBLEM

R/M POLY-V® DRIVE... MORE USE PER DOLLAR

Heavy loads can slow down ordinary gang saw drives . . . even throw off belts where conventional multiple V-belt drives are used. Not so with R/M Poly-V Drive. Design features of R/M's patented heavy duty drive assure constant belt speed ratios from *no* load to *full* load . . . *uniform* power delivery *without* loss in drive speed under the most rugged operating conditions and heaviest production schedules.

No drive delivers as much power in as little space as Poly-V* Drive. Single unit V-ribbed belt design provides *twice* the tractive surface of V-belts to deliver up to 50% more power in the *same* space as a multiple-belt drive . . . or *equal* power in as little as ⅔ the space! There are no belt "matching" problems with Poly-V, no equipment downtime for individual belt replacement. And because drive life is not limited to individual belt life, you get longer, trouble-free service on the job.

Just *two* Poly-V belt cross sections meet *every* heavy duty power transmission drive requirement. Let R/M engineers assist you in determining the best installation for your application. Contact your R/M representative . . . or write for Bulletin #M141.

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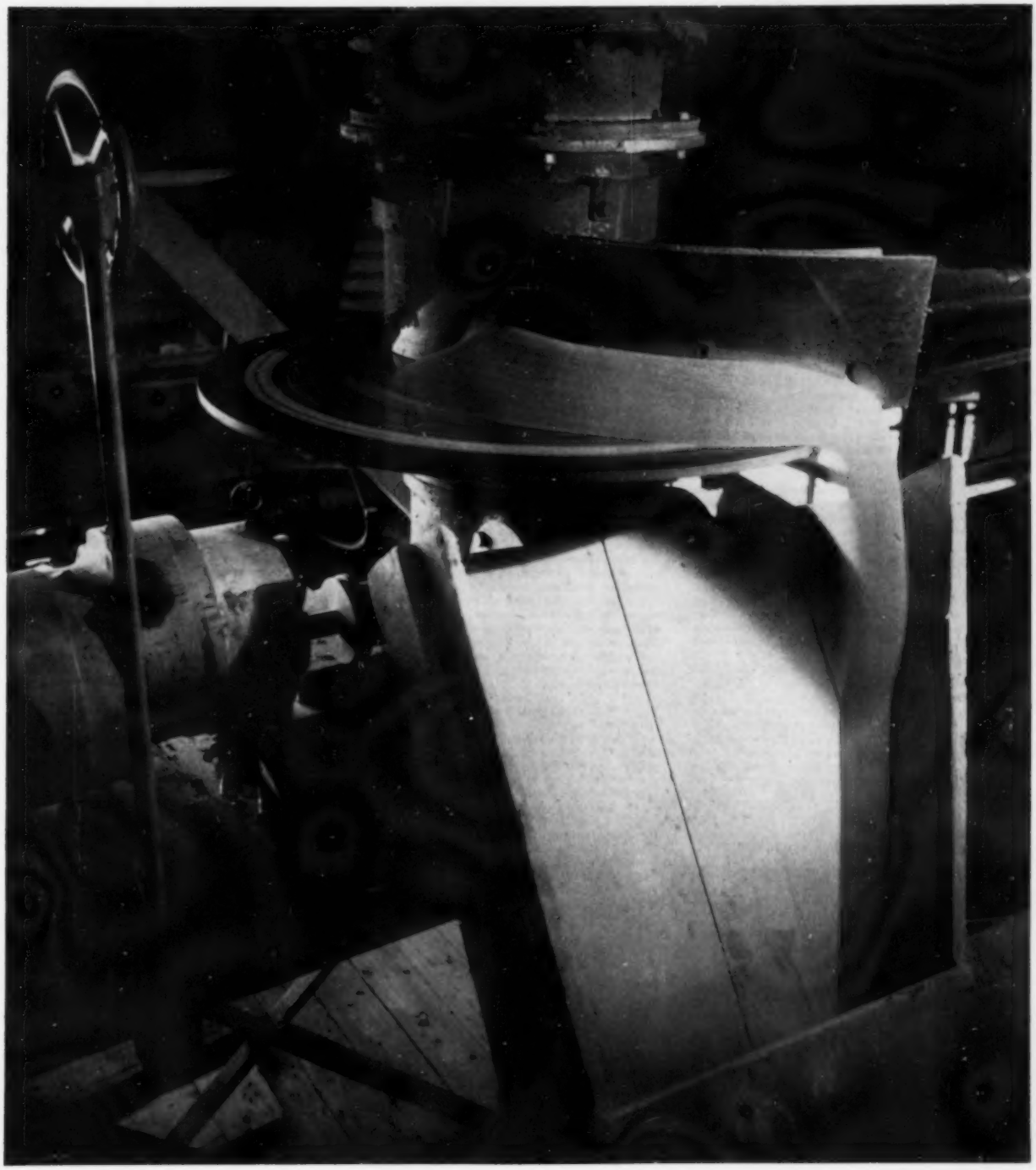
SPECIAL:

CLAY MODIFIERS ISSUE

Body Conditioners
Coloring Agents
Deflocculents
Binders
Fluxes



Clay Modifiers

Completely revised and brought up to date, the editors of B&CR have compiled a complete, concise summary of materials that you can use to control: firing, drying, forming, texture, color, porosity, weight, strength and size.

Albany Slip Clay

A low fusion point clay with a PCE of 3-5. The standard material comes from West Albany, N. Y., and gives a brown glaze. Its application in structural clay is principally for the interior glazing of sewer pipe. For such use it is slurried and applied by spraying or dipping. It has also been used as a flux and color stabilizer in quarry tile. The clay is available in lump and airfloated form.

Alumina

Al_2O_3. A material appearing in several crystalline forms, of which alpha-Al_2O_3 is the densest and most stable. Native alumina is found as the mineral corundum, having a hardness of 9.0 on the Mohs scale, and long used as an abrasive and for jewels as ruby and sapphire. The hydrated phases, gibbsite, diaspore and boehmite are also found in nature.

Although alumina occurs commonly combined as silicates in clay, feldspar, kyanite and many other minerals, the principal sources of purified alumina and hydrated alumina are native bauxites and laterites from which large tonnages are extracted annually by the Bayer process.

Bayer aluminas are available in a wide range of physical properties mainly as a result of control of crystal size and chemical reactivity during their production. Their high purity with respect to iron and fluxing impurities make them suitable for many ceramic applications in the refractory, abrasive and alumina porcelain fields.

Four types of alumina are generally considered for use in ceramic products: They are Calcined, Tabular, Fused and Hydrated aluminas.

Fused alumina is produced in large tonnages by an electrothermal process from bauxite and Bayer alumina for abrasive purposes, and although it is exceeded slightly in hardness by silicon carbide and some other synthetic abrasives, it is superior in toughness and is recommended particularly for metal grinding.

The addition of alumina to fireclays increases refractoriness, load-bearing ability and spalling resistance. A new type of high temperature insulating refractory is made from fused alumina bubbles, or hollow spheres, bonded and high fired.

This material is supplied as a castable which can be formed into the desired shape on the job and provides protection up to 3300°F. Calcined alumina and bauxite as well as tabular alumina grog are used in large tonnages to increase the alumina content of refractories. Calcined, sintered and fused aluminas constitute the base materials in a class of special refractories containing from 90 to 99% alumina, used in the form of refractory brick or monolithic liners.

Calcined alumina is added to native kyanite to adjust the alumina-silica ratio during conversion to mullite. High purity synthetic mullite is produced from alumina and low iron clay, mixed in suitable proportion to form $3Al_2O_3 \cdot 2SiO_2$ and converted by sintering or fusion. A synthetic, high-temperature, thermal insulator has been developed recently which consists substantially of mullite in the fibrous form.

Alumina is used in producing refractory calcium aluminate cements which set by hydraulic bonding. In rammed and castable compositions with refractory grogs, these cements retain good bonding strength in their effective service range. Calcium aluminate cements, prepared from Bayer alumina, may have pyrometric cone equivalents above 35.

High alumina bodies exhibit great resistance to mechanical abrasion in addition to their more widely used resistance to heat. In some formulations the service life of these materials exceeds that of hardened steel by 30-50 times.

In glazes, alumina is the means for regulating the oxygen ratio to control matteness or brilliance. The best aluminate silica ratio in conventional glaze has been found to be between 1:6 and 1:10. In glaze containing at least 0.1 equivalent of alumina, the further addition of alumina raises the deformation or maturing point. An important function of alumina is its prevention of glaze devitrification. It increases viscosity, refractoriness and opacity. In general, it increases the resistance both to chemical attack and impact resistance, tensile strength, hardness and weathering. The chief sources of alumina equivalents for glazes are feldspar and clay.

Ammonia

NH_3. This material can be used to control the pH of clays. Where the high acid condition of a naturally occurring clay is such as to cause trouble in the dryer, especially with peeling glazes, ammonia can be added to the pugging water to control the condition. Two forms are available, the anhydrous, a gas sold in drums. Ammonia Hydroxide is a liquid and is available in cans, drums or carloads. It has been found that additions of ammonia also will affect black coring and, if the problem is not too severe, will control it. Scumming is also affected when not too severe. The pH appears to be best adjusted between five and ten.

Ammonium Chloride

NH_4Cl. One of a group of materials which, by affecting the temperature of the dissociation of the sulphur compounds occurring in structural ware clays, can effectively reduce the time required to fire ware without black-coring. Due to the corrosiveness of the compound the problems connected with its use have been overcome with the addition of ammonia and ammonia bicarbonate. However, according to a patent, U.S. #2,838,410 assigned to the Spencer Chemical Co., the more effective treatments consist of application of up to .2% of a solution of Ammonium Nitrate and Ammonia or Ammonium Bicarbonate. Other combinations are said to be effective in the elimination of black coring.

Ammonium Nitrate

NH_4NO_3. (See Above)

Andalusite

$Al_2O_3 \cdot SiO_2$. The same chemical composition as sillimanite and kyanite with which andalusite forms a trimorphic series. Andalusite is orthohombic, has a specific gravity of 3-3.5 and a hardness of 7.0-7.5. Special varieties are known as Chiastolite and Viridine.

As mined for commercial use, the ore generally contains 75-85% andalusite. Minor amounts of pyrophyllite, mica, rutile and corundum are frequently present as associated minerals. The andalusite now mined in the United States comes from White Mountain in the Inyo range, Mono County, California. Deposits of commercial grade andalusite discovered to date are relatively rare, but reserves of some promise are found in Nevada, New England, Brazil, Australia, Sweden, France, Russia, Germany and Spain.

Andalusite has been used principally in spark plug porcelains and special refractories for high temperature service. The current and potential uses are limited by its availability. Along with kyanite and sillimanite it is promising as a mullite forming mineral. Andalusite, if available economically, would often be preferred for mullite type refractory bodies, since its volume stability, refractoriness, and ready conversion to mullite are desired characteristics.

Anhydrous Rasorite

An anhydrous sodium borate concentrate containing approximately 90% Na_2O, B_2O_3 and 10% of a complex insoluble clay. An addition of 6% of this material to salt used in salt glazing sewer pipe and facing materials will increase glaze thickness, reduce pinholing and crazing and generally improve the appearance of the pipe. It offers a more economical source of B_2O_3 than the refined sodium borates and can readily be substituted for either borax or anhydrous borax on an equivalent basis. (59 pounds are equivalent to 100 pounds of the hydrated borax and 111 pounds are equivalent to 100 pounds of the anhydrous borax.) The constituents contained in the insoluble clay are silica, lime, magnesia, alumina, titania and a small quantity of iron oxide.

Aplite

A fine grained rock largely composed of plagioclase feldspar, divided between albite ($Na_2O \cdot Al_2O_3 \cdot 6\ SiO_2$) and anorthite ($CaO \cdot Al_2O_3 \cdot 2\ SiO_2$) in the ratio of approximately 60% and 40%, respectively. Secondary zoisite ($4CaO \cdot 3Al_2O_3 \cdot 6\ SiO_2 \cdot H_2O$) and muscavite ($K_2O \cdot 3Al_2O_3 \cdot 6SiO_2 \cdot 2H_2O$) are associated with the basic minerals. The rock could more properly be called anorthosite or andesinite mineralogically, but the industry has widely accepted the name Aplite.

The material has a PCE of 8-9 and, in general, shares the attributes of other feldspars and nepheline syenite. Commercial production is centered in western Virginia. The grades used by the structural clay products industry are generally by-products available at low cost. Granular and fine-particle grades are sold.

Aplite is used as a molding sand in soft-mud brick, alone or in combination with other sands and coloring materials. Similarly used in stiff-mud brick in the rubbing box or by sand-blasting methods. Various desired colors are obtained in these ways. Typically gives pink effect when used alone on red brick.

The coloring principle is apparently optical, little or no fusion being experienced at typical production temperatures. The latter fact requires adherence additives, such as borax, in soft-mud brick.

In face brick and other structural products Aplite serves as a low-cost flux where operating temperatures are suitable to encourage eutectic formation. Aplite producers supply low-cost material in a variety of screen sizes permitting its use as a grog to control drying and shrinkage in low-temperature operations.

Barium Carbonate

$BaCO_3$. Insoluble in water but soluble in acids. Melts at 1,360°C. Poisonous. Occurs as the mineral witherite, which is mined in England and California. The precipitated barium carbonate used in ceramics is obtained from barytes which is reduced to soluble barium sulfide and converted to the carbonate by precipitation with soda ash.

Barium carbonate is used in glazes as a flux or to assist in the formation of a matt structure. Barium forms silicates slowly, but when barium is completely combined, it becomes almost as active a fluxing agent as lead oxide. When used in glazes in amounts greater than .1 equivalent, it renders the glaze too refractory for commercial firing.

It is used in large tonnages in the brick and sewer pipe plants to control dryer house scum and efflorescence. Dryer house scum develops when the water used in preparing the brick or pipe is evaporated in the dryer. Soluble salts, the most common of which are calcium sulfate and magnesium sulfate migrate to the exposed surfaces and are combined with the body to form complex insoluble white marks in the firing process.

Barium carbonate dosing precipitates the salts and the resulting compounds remain locked in the interior of the brick. The typical reactions are $BaCO_3 + MgSO_4 \rightarrow BaSO_4 MgCO_3$. Other sulfates causing these difficulties are those of sodium and potassium. Brick containing free lime are subject to scumming in the kiln if sulphur bearing gases strike them when they are below the dew point of the kiln gases.

Barium carbonate can be added as a slurry or dry and should be used as early in the production line as is possible. The quantity of sulfate salts varies widely in the same pits and therefore the quantity of barium required will fluctuate widely. The most satisfactory way to determine amount needed is to make test brick from selected samples and maintain a record of barium required for material from each pit area.

Plants stockpiling raw material for later use can apply part or all of the barium requirement to stock piled material as it is laid down. In this connection it is worth noting that stockpiling can add to scumming difficulties if the clay contains appreciable amounts of pyrites, which can, under certain conditions, break down to form sulphuric acid which then combines to form soluble salts.

Each load of material dumped into the grinder can be treated with barium applied in batches or the barium can be added with a sensitive feeder continuously. It can be added to material drawn from storage while being conveyed to the pugger. Barium and water slurry can be added at the pug mill as all or part of the water added to develop plasticity.

Barytes

$BaSO_4$. A natural mineral found in Missouri, Georgia, Tennessee, California, Virginia and other states. It is the chief ore from which precipitated barium carbonate is manufactured, but may sometimes be used in the natural state. It has been demonstrated that this ore, which is reasonably pure and unadulterated, can be used as a batch constituent in glazes, although its use entails special handling problems and the batch must be fritted.

Bauxite

A non-plastic claylike material used in the production of aluminum metal and aluminum oxide for the ceramic field and the chemical industry. It is used by itself as an addition to abrasives, refractories, cements and other ceramics.

The amounts of silica, iron and water present in bauxites control the value for use in refractories, abrasives and in cements. For refractory purposes a calcined bauxite of high alumina content, controlled low iron and low loss on ignition is required. It is an excellent material for refractory brick, provided adequate attention is given to initial calcining to take care of the tendency of bauxite with residual moisture to shrink at the temperatures at which the refractories are used. Bauxite refractories have adequate strength when cold and at working temperatures. They resist cracking, spalling and chemical and physical reaction with the furnace charges with which they come into contact.

Mullite refractories are produced from mixtures of bauxite and silica sand or quartz by the sinter-bonded method or by the electrically fused-cast method, in which case the starting material is alumina derived from bauxite.

The chief uses of bauxite refractories are: For linings in rotary kilns for the manufacture of portland cement, dolomite and lime; for lining in combustion chambers of boiler installations for use in ceramic industries, e.g. glass tank blocks, furnace parts, regenerator wall construction and in checkers; in the metals industry for center walls of zinc distillation furnaces, bottoms of malleable iron furnaces, water cooled parts of basic open hearth furnaces and in all types of furnaces where the ash has a high corrosive effect on brick.

In recent years bauxite has been used in increasing quantities for the manufacture of special quick hardening high alumina cements. These cements are prepared in blast furnaces, rotary kilns or electric furnaces by the fusion of bauxite and limestone. The resulting product consists of a mixture of calcium aluminates and calcium aluminum silicates with some iron oxide and possibly some calcium silicates.

Bauxite abrasives are prepared by fusion of a mixture of calcined bauxite, coke and iron turnings in an arc type electric furnace at temperatures above 2,000°F. Massive corundum crystals containing 94-95% aluminum oxide result. These are crushed, ground and separated into various grit or grain sizes which are then manufactured into abrasive products such as grinding wheels, abrasive stones, abrasive cloths and papers and grinding and polishing powders. Fused alumina grinding wheels are made of the material and used extensively in the metals industries in grinding and polishing.

Bentonite

A natural clay-like substance. A hydrous silicate of alumina. Derived from volcanic ash, with the clay mineral, montmorillonite ($Al_2O_3 4SiO_2 9H_2O$) as the chief constituent. The name of bentonite originally applied only to a specific type that occurs in the Fort Benton formation in the Black Hills of Wyoming and South Dakota. Later all clays comprising chiefly montmorillonite and derived from volcanic ash were classed as bentonites. For practical purposes it is necessary to subdivide bentonite into two types: (1) Those that swell enormously when wetted, and (2) those that swell no more than other plastic clays. Type 2 is widely used as a clarifying clay, as a carrier and sticking agent for insecticides, and for improving plasticity and workability in ware where color is not important, such as sewer pipe.

From 1% to 3% of bentonite is used successfully in high temperature cements, mortars and various plastic refractories. Bentonite is also used in structural ware to insure sharp edges, high green dry and fired strengths. As low as ¼% of bentonite prevents glazes from settling; high film strengths are obtained.

Beryl

$3BeO Al_2O_3 6SiO_2$. It is the ore from which Beryllium oxide is recovered by treatment of the ore with sodium silico-fluoride at 850°C. The resulting sodium fluoberyllate is dissolved in boiling water, filtered and the oxide precipitated with caustic. At present it is the only commercial source and consequently of prime importance.

To one interested in colored glazes, beryl offers an unusual property, the ability to produce high-temperature chrome greens.

Beryllium Oxide

(BeO)Beryllia. Melting point 2510°C, specific gravity 3.0. This material, with very high thermal conductivity, good heat stock resistance and a hardness of 9 on the Mohs scale has been used for the production of very high temperature melting crucibles.

Bodies can be formed from a mix of high temperature grog and about one third fine, low temperature calcined oxide. Wax is used as a lubricant in the mix and, after pressing on a high pressure press with polished dies, the wax is carefully driven off with moderate firing schedules and final firing of the body can be carried out as high as 3,600°F.

Beryllia crucibles are useful in the melting of pure metals as the low reactivity retards contamination while the high working temperatures and shock resistance ease techniques. The literature takes note of the health hazards with special reference to the unpredictable susceptibility of certain individuals to dusts or vapors of the metal and its compounds and for this reason precautions should be taken to prevent exposure.

Binders

A fairly large group of organic materials which can be used in processing all types of clay and non-clay bodies to affect the mixing, forming and drying characteristics. On firing, the binding material is oxidized and leaves the body without entering chemical combination with the materials of the body, although the physical make up of the fired body may be radically affected.

By proper selection of binders an operator can:

1. Increase water of plasticity.
2. Decrease water of plasticity.
3. Increase green strength.
4. Increase dry strength.
5. Increase fired strength.
6. Increase hardness in the green and dried state.
7. Change the rate and total absorption of fired ware.
8. Change shrinkage in the dryer and kiln.
9. Reduce power required for forming.
10. Reduce warping, chipping and cracking.

All of these effects tend to improve the recovery of first class material from the kiln. These few plants enjoying a 100% recovery, of course, have little to gain unless greater drying and firing rates are desired, but as dryer and kiln losses rise the economic justification of binders becomes evident.

A number of materials are available which will affect the raw clay. A program of testing should be carried out to determine the most economic with any particular clay. Different clays react quite differently with the same treatment and what proves to be best in one instance is not apt to be so in the next.

A preliminary study indicates that the following materials should be considered in any binder study.

1. Natural gums
2. Alginates
3. Waxes
4. Alcohols
6. Celluloses
7. Lignins

Gums, because of their relative high cost, are seldom used in structural units; however the gum group, which includes arabic, tragacanth, ghatti, locust seed and karaya have been used for many years as binder to improve adherence of glazes and engobes to green and dried ware and in such application should be considered.

Another high cost group of binders are the alginates. These materials are hydrophilic colloids derived from sea weed such as kelp from the Pacific coast. For the most part these binders replace the natural gums in glazes and engobes. Small additions have pronounced effects.

Waxes are derived from both vegetable and mineral sources. Used in the form of emulsions the waxes may be used singly or in blends. The effect is twofold: in addition to serving as a binder they act as a good lubricant to bodies of little plasticity. In dust pressing, close size tolerances can be maintained, dry press operations can be carried out under higher pressures without pressure cracking and in stiff mud extrusion, laminations are reduced. Waxes have been specially developed for use in glazes and engobes to improve rub resistance.

Flours and starches are prepared from vegetable sources; potato, wheat and rice have been used but corn starch and corn starch derivatives are popular because of cost and ready availability as well as the wide range of corn products offered.

Dextrines are sugars converted from starch by acid treatments and are used in specific applications in the same way as starch.

In extruded materials, various dextrines and Corn Products' Hydrocar brand binder are used to obtain added strength while green and during the first stages of drying. Globe brand dextrine, which can be used in this application, requires one to three pounds per ton of clay. It is a powder and highly soluble in water. Hydrocar and dextrines are

Clay Modifiers • Body Conditioners

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used in the refractory field, but here the plasticizing effect of the material is more important than the added strength.

Some corn cereal binders are used to reduce loss in the production of sewer pipe. A product used in this application is Mogul cereal binder, a pregelatinized corn starch product containing 5-7% corn protein. It is powder in form. Approximately ¼ of 1% is used to obtain maximum green strength.

The same material is also used in the production of face brick to cut losses. An addition of 1% can cut breakage 100% and only ½ of 1% will reduce such breakage significantly.

Polyvinyl alcohol is a white, water soluble powder which possesses excellent adhesive and binding characteristics. Films cast from aqueous solutions of polyvinyl alcohol have extremely high tensile strength and are impervious to oils and greases. By varying the conditions during manufacture, it is possible to produce a series of polyvinyl alcohols differing markedly in physical properties. The principal factors governing these properties are the degrees of polymerization and hydrolysis.

With each viscosity or polymerization range, several grades of polyvinyl alcohol are produced by varying the degrees of hydrolysis of the polyvinyl acetate. Of these hydrolyzed, about 99% or greater are generally referred to as "completely hydrolyzed," while those hydrolyzed to a lesser extent are referred to as 'partially hydrolyzed" grades.

The two grades of Du Pont's polyvinyl alcohol generally used as binders for clay are "Elvanol" 72-60 and "Elvanol" 71-30. Where economic limitations are severe it can be combined with starch to reduce costs. For initial trials, one part of PVA to nine parts of a low viscosity, oxidized starch is suggested. Even in smaller proportion, "Elvanol," mixed with starch, will produce a noticeable improvement in binding characteristics over starch alone.

Methylcellulose, a synthetic gum, is an effective binder for refractories, structural clay products and abrasives. In addition, it functions as a lubricant, wetting agent and plasticizer. As a film former it toughens unfired glazes and improves bonding.

It has been used as a body addition and is highly regarded as a component of refractory mortars where its water retaining properties increase workability.

Both Du Pont's CMC and Dow's Methocel are produced in a range of qualities and viscosities with different effects. For this reason, product literature should be studied to insure economical results.

A large number of wood extracts are offered and because of their low cost, are logical products for consideration by structural producers who have production of large tonnages.

These products are available as liquids and powders, both relatively refined and unrefined and exhibit a rather wide range of properties.

Some are calcium based, some are sodium based and with different clays results may be expected to vary. The degree of sulfonation is also subject to control.

Lignins should be added, as all binders, with accurate feeders as the actual addition is very small and variations in the rate will produce problems greater than the original ones.

Lignins are by-products of the paper industry and have been used in the structural clay industry for many years. A sewer pipe manufacturer reports elimination of a high cost plastic clay, added at a 30% rate, when a ½% addition of "Goulac" a Robeson Process Co. product was used and several face brick manufacturers have indicated a 50% reduction in pugging water while using Kimberly-Clark's "Additive A."

Mixtures of binders from the different classes sometimes are much more effective than when either is used alone. A laboratory testing program should be undertaken by producers interested in binders with the idea of determining most promising binders for plant scale trials.

Body Stains

They are combinations of various oxides calcined together at high temperatures. The most common system is composed of oxides of chromium, antimony, and titanium, which yields a wide variety of yellow, tan, and brown shades. A uniform color through the body is produced by mixing the body stain with the raw material before forming. Cobalt aluminates or silicates are used for blues, manganese alumina calcines for pinks and chrome based stains for greens.

Borax

$Na_2O{:}2B_2O_3{:}10\ H_2O$. Practically all American Borax comes from California. The mineral tincal is mined in the Mojave Desert and is processed and marketed as Borax. Borax is also prepared by the evaporation and purification of brines from Searles Lake. It is soluble in water and soluble in acids and melts in its own water of crystallization. It has a mol. wt. of 381.43, sp. gr. of about 1.72 and a hardness of 2.0-2.5.

The water of crystallization is eliminated during fusion with other ceramic raw materials, leaving 52.8% by weight of sodium and boric oxides to form part of the ceramic composition. The purity of ordinary commercial borax is guaranteed over 99.5%, the original impurity being largely clay. It is obtainable in large crystals, powdered, and granular form. The last being regarded as the most practical and economical for ceramic use.

Anhydrous or fused borax, $Na_2O : 2B_2O_3$, melts at 736°C and is soluble in water, its rate of solubility being considerably slower than borax at 20°C but about the same at 60°C. Theoretically it contains no water of crystallization, and actual analyses show less than 0.5% water. Anhydrous borax may be substituted for ordinary borax, approximately 53 lbs. being equivalent to 100 lbs. of the hydrated material. Unlike borax, it does not puff or swell to a light fluffy mass during the melting operation, and therefore its use minimizes segregation and loss, particularly in furnaces operated under strong drafts.

Borax is widely used as a flux for glazes on ceramic bodies. The boric oxide shares with silica the property of combining with bases to form glassy compounds after fusion. The readiness with which boric oxide combines with bases finds application in the production of pottery colors from metallic oxides; the shades obtained often vary according to the percentage of boric oxide used. It also has an important function in reducing the viscosity of glazes; by the addition of a little borax, the most viscous glazes are made to heal better. Borax also tends to produce higher gloss in a glaze and lowers the maturing temperature.

Borax is used mixed with salt in vapor glazing of sewer pipe and structurals. In most cases the optimum amount of borax is 10% and the balance salt. The mixture is applied in the same manner that salt alone is used in salt glazing. The major result is a reduction of crazing and pinholing with a significant increase in glaze thickness. (See anhydrous rasorite.)

Boric Acid

$\frac{1}{2}(B_2O_3{:}3H_2O)$. Boric acid is produced by treatment of borax with sulfuric acid and occurs, in limited quantities, as the mineral sassolite in Italy. It is not as economical a source of boric oxide as borax. It can be used where the addition of sodium must be limited.

Calcined Clay

Any clay when heated to a low red heat loses many of its claylike properties; the ability to form a plastic mass is probably the most important followed by the permanent reduction in size. Strictly speaking, grog, made by grinding cull fired clay bodies and calcined clay are identical but their physical condition may vary within wide limits.

Calcined clay can be prepared by passing through a rotary kiln or by any of a number of batch methods. Power to form a plastic mass is lost around 1,200°F but the ultimate shrinkage is not reached until the material is heated to much higher temperatures. This ultimate temperature will vary with different clays and its necessity will depend on the use to be made of the resulting material.

The addition of calcined clay to highly plastic clays will reduce the plasticity of the mixture to any desired point. In the production of structural products it will increase the production rates from grinding, tempering and extrusion operations. By reducing shrinkage in the dryer and the kiln, serious production bottlenecks can be overcome with an important increase in quality.

An important percentage of refractories contain calcined clay usually in the form of grog. (See Grog.)

Calcium Carbonate. (See Lime)

Calcium Fluoride. (See fluorspar)

Calcium Aluminate

A pure hydraulically setting calcium aluminate cement is available for applications requiring high refractoriness. This material is made from Bayer process alumina and high-grade lime and contains less than 2% total impurities. It contains 80% Al_2O_3 and 18% CaO. A typical chemical analysis is as follows:

CaO	18%
Al_2O_3	80%
Fe_2O_3	0.4%
SiO_2	0.1%
Na_2O	0.5%
MgO	0.4%
S	0.06
Ignition Loss	1.0

PCE — 34 (3205°F.)

This cement can be used with conventional fire clay grogs as well as super refractory grogs such as Tabular Alumina. The hydraulic compounds formed in setting are $CaO \cdot Al_2O_3$ and $CaO \cdot 2Al_2O_3$. These have high bonding strength at room temperature and above. At 2000°F the hydraulic bond is destroyed but ceramic bonding then takes place and high strength continues up to the softening point, 3200°F.

Pure calcium aluminate cement has appreciably higher strength than impure calcium aluminate made from bauxite in the critical temperature range, 1500 to 2000°F., where the hydraulic bond is lost and the ceramic bond is not yet formed. In fact pure calcium aluminate cement with a grog of Tabular Alumina, 15% cement and 85% Tabular Alumina (Cal Tab 15) has even higher strength at 2000°F than at room temperature, as shown in the following data:

Cal Tab 15	Modulus of Rupture (psi.)
As cast, 24-hour cure	650
Fired 5 hours at 2000°F.	1200

Calcium Oxide. (See Lime)

Calcium Sulfate. (See Plaster of Paris)

Carbon

A growing number of refractory brick are being produced that contain elemental carbon as the refractory material. Coke ground and graded is a popular source of the material, which is held together with tar. These brick are used in the metal producing industries in places where they are protected from exposure to oxygen. Used with reason, carbon brick are reported to offer outstanding advantages of high refractoriness, low and uniform expansion under heat, and high thermal shock resistance.

In addition to coke they can be made of charcoal, anthracite, petroleum coke or graphite. Tar binder is mixed with the carbon and pressed with mechanical presses, dried in unheated rooms and fired in kilns from which all oxygen is excluded from the setting.

Clays

Clays are chiefly made up of hydrated aluminum silicates. The most common of these is the kaolinite group ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$) and the montmorillonite group ($(Mg, Ca)O \cdot Al_2O_3 \cdot 5SiO_2 \cdot nH_2O$.

There are two types of clays, the residual and secondary. The residual occurs in the place where it was developed by weathering. Secondary clays are transported from the original site by water or other means as ice and deposited in a remote area.

The pure kaolinite and montmorillonite clays are made of very minute plate-like structures, and these plates are responsible for the plasticity of the clay when mixed with water.

The normal behaviors of clays in the ceramic process is to develop plasticity, have a formability, have a rigid state and fire to a stone-like hardness, developing various colors.

The exceedingly high content of fine particles is characteristic of very plastic clays, and has a direct relationship to their working properties. The finest portion contains the clay suspensoids or colloids which are responsible for the plasticity. The greater part of this fine material consists of granular material while the colloids are really only a very small amount. A high content of the so-called clay substances is sometimes accompanied by an excessive degree of plasticity which renders a clay sticky and difficult to work. Other very important factors in plasticity are the amount, size, relative proportion of sizes, shape and character of the granular material, and the amount and character of the soluble salts, i.e., electrolytes present.

The influence of the fineness of grain of a clay is not limited solely to its relation to plasticity, but extends to other properties, namely, drying conduct, drying shrinkage, warping, tensile or transverse strength and bonding strength.

It may be said that the greater the proportion of the fine material, the slower the rate of drying, the greater the shrinkage and the greater the tendency to warping and cracking during this stage. It is the usual practice to mix these clays with coarser materials which overcome these difficulties.

If we compare two clays of different degrees of plasticity, we find that the more plastic requires more water to make it workable and that the loss of water in the drying operation takes place more gradually because of the very extensive capillary system. Also we find that there is a greater shrinkage in the highly plastic clay.

Clay, Ball

Ball clays are aluminum silicates found chiefly in Kentucky and Tennessee. They are very plastic sedimentary clays which are fairly refractory, maturing from Cone 18 to Cone 34. It will burn to a rather near white color. Some ball clays will vitrify as low as Cone 8 and 10.

The refractories industry is a large user of ball clays, particularly in the ramming mixes, castables and plastic refractories. Since all of these must be put in place and remain rather hard before being matured in clay, such as ball clay, which has high plasticity and high dry strength, is used to develop the strength of this refractory in dry state. Ball clays are very workable into shapes and holds its shape after once formed.

Special refractories which require a great amount of prefired grog material need some plastic clay to hold the shape of a brick or a special shape. This plastic is ball clay. In some cases, as little as 10 or 15% ball clay is used to suspend 85 to 90% of grog.

Some ball clays are used in engobes to decorate brick and tile. Since ball clays are quite plastic, they are moderated with flint and color to match body shrinkages of brick and tile and make a good coating surface in any color.

Ball clays are used normally in the heavy clay products industry for their plasticity in the working stage, and for dry strength in the dry stage. In some instances, in colored brick surface.

Chromium Oxide

Cr_2O_3. Mol. wt. 152, sp. gr. 5. A bright green crystalline powder insoluble in acids and alkalies.

Chromium is used mainly to impart a green color. It is most often introduced as a chromium oxide or potassium dichromate, but the dichromates of sodium and ammonium and the chromates of potassium, sodium and iron find occasional use.

In glazes, chromium oxide, or other chromium compounds, are commonly used to produce green colors. The oxide itself is generally used in raw glazes while potassium dichromate is more common in fritted glazes. An oxidizing fire must be provided to avoid development of a black color.

In such glazes, zinc oxide will produce a brown color, due to the formation of zinc chromate, and high lead glazes will form the yellow lead chromate. Tin oxide, of course, cannot be present, as it will form the chrome-tin pink.

Coal

This is an amorphous form of carbon and has its origin in vegetable matter which has become decomposed by chemical activity and often pressure. Widely used as a fuel in the structural and refractory industry, it has been replaced by gas or oil in many plants.

It is used as a grog-like material in some plants to expedite forming of brick. In this use it acts to reduce lamination due to the keying action of the coal particles promoting greater production and better quality. Due to the sulphur content, it can add to the scumming problems of a producer.

All of the heat value is recovered from the coal which can be added in the pug mill or can be ground with the clay in the grinders. Some clays are naturally rich in carbonaceous material, similar to coal, and furnish much of the heat required to raise the body to the maturing temperature. An additional effect of the coal is the reduction of the unit weight of the ware.

Coal also serves as the raw material for the production of coke, which can be used in brick similarly and which is also used in the production of light weight aggregate and as a raw material for the manufacture of carbon refractory brick.

Anthracite coal can be used for the fuel in lightweight aggregate production; in this use, the ash becomes part of the product.

Cobalt Oxide

Co_3O_4 : CoO. Mol. wt. 240.8 and sp. gr. 6. Insoluble in water and most mineral acids, but soluble in sulfuric acid. This black powder is obtained by roasting cobalt ore from Northern Rhodesia, Morocco, Burma and Canada in order to drive off arsenic and sulfur, and then, by separating the residue from the nickel and other constituents.

Cobalt oxide is widely used in the ceramic industry as a source of colorant for glass, glaze stains, body stains and engobe stains. Best results are obtained by first calcining intimate mixtures of cobalt oxide with such other ingredients as aluminum oxide, silicon dioxide, zinc oxide and magnesium oxide. The above produces straight blue stains going toward the green as the zinc oxide is increased and going toward the purple as the silicon dioxide and magnesium oxide are increased.

By adding chrome oxide to the above, shades of blue green are produced.

Cobalt oxide calcined with combinations of iron oxide, chrome oxide, nickel oxide and manganese dioxide produce shades of gray and black.

Stains can be used in connection with glazes, which are compounded from alumina as a base, with lighter blues than the usual cobalt are obtained. In the case of high cobalt content, there is a slight tendency toward a greenish tint when low fire is given. In proper combination with MgO, SiO_2, and B_2O_3, a beautiful red, violet, lavender or pink color can be obtained. Cobalt in combination with manganese is also used in the production of black spots on terra cotta glazes.

Cobalt Sulfate

This material can be used to impart a blue or blue-white color to white bodies. The sulfate is dissolved, added to the body and then precipitated with sodium carbonate. The effect of as small an amount as one pound of cobalt sulfate on one ton of clay will be noticeable.

Colemanite

A natural hydrated calcium borate, $2\,CaO \cdot 3B_2O_3 \cdot 5H_2O$. It occurs in California and Nevada and was formerly the chief domestic source of borax and boric acid.

Colemanite can be used very satisfactorily in many raw lead glazes where the addition of CaO and B_2O_3 is desired without using a frit. It is especially useful in the development of some pink and maroon red glazes, both matt and bright, at temperatures from Cone 01 to Cone 07. It has been found that this material can be used in place of high whiting content and that it will bring out better shades of pinks and maroon in commercially prepared stains.

Copper Oxide

Two materials, Cupric oxide, CuO, or Cuprous oxide, Cu_2O, are used as a source for copper oxide. Cupric, insoluble in water is derived by the ignition of copper carbonate or copper nitrate, copper hydrate, or oxidation of lower oxides. Cuprous is prepared by the oxidation of copper, by the addition of bases to cuprous chloride, or by the action of glucose on cupric hydroxide or upon copper scale.

Cupric oxide, when used in glazes, has a wide range of color. It may be used either as the raw oxide in a raw glaze, as the raw oxide in a fritted glaze, or as a part of the frit itself. It is used equally well in any of these cases, but, when mixed with the frit, there is a loss of color strength under certain conditions due to volatilization of the oxide, and it is not so satisfactory above Cone 4 when operations are carried out under oxidizing conditions.

Copper oxide is the only individual pigmentary oxide in common use which in practically every combination and under ordinary conditions produces clear green colors. In combination with tin oxide and other opacifying agents, it gives turquoise or blue-greens when the glaze is alkaline.

The amount of copper oxide in the glaze for light shade of green will be 0.03 to 0.06 equivalents, and for darker shades from 0.06 to 0.10 equivalents. The variable amount will depend almost entirely upon the composition of the RO group. In glazes containing PbO in fairly large amounts, smaller than normal amounts of copper oxide are used.

Copper Carbonate

$CuCO_3 \cdot Cu(OH)_2$. It is derived from the interaction of sodium carbonate and copper sulfate.

Copper

Copper carbonate is used to introduce copper colors into glazes, especially in cases where, instead of getting the blues and greens of copper oxide, it is desirable to get the lavenders, reds and purples obtainable under reducing conditions. A brilliant red glaze is produced with 0.2-1% copper carbonate, 1% tin oxide and a reducing agent of 0.2% silicon carbide.

If, in the same glaze, the silicon carbide is omitted and the stannic oxide increased to 5-7%, a blue results, thus allowing the development of copper reds and blues or greens on the same piece.

Cordierite

Cordierite is a magnesium aluminum silicate with the following formula: $2MgO \cdot 2Al_2O_3 \cdot 5SiO_2$. Its specific gravity is rather high, ranging from 2.6 to 2.7 and it is the hardness of colindite ranging from 7.0 to 7.5 on the Mohs scale.

Although cordierite is found over the world, it is chiefly developed in clay bodies by adding talc to a rather pure clay.

Cordierite, which is theoretically 39.6% talc, 47.0% clay and 13.4% alumina, has an extremely low coefficient of expansion. It can be heated up very rapidly and cooled down very rapidly. Repeated heatings and coolings do not affect it.

By itself, this composition has a very short vitrification range and must be fired very carefully. In fact, it cannot be fired too successfully in commercial kilns. Zirconium silicate is used as a modifier for this body, giving it a better firing range so that it can be fully developed in a commercial kiln.

Cordierite type compositions have been used for insulation in high temperature operating mechanisms as motors, radar, and so forth. Its use in general run of refractories is yet to be developed to a high degree.

Crocus Martis

An oxide of iron used mostly in the preparations of underglaze colors and sometimes in glazes as a coloring agent. It develops, when burned in an oxidizing flame together with other glaze constituents, a reddish-brown color.

Clay Modifiers. Body Conditioners

Coloring Agents • Deflocculants • Binders • Fluxes

Cryolite

A mineral, sodium fluoaluminate, having chemical composition Na_3AlF_6. The refined material is sold under the trade name Kryolith and is available as a minus 80 mesh powder in 100-lb. bags.

Cryolite can be used in clay products as an auxiliary flux. Its Fluorine content aids in dissolving silicates. As a mineralizer, Cryolite promotes Mullite formation. Cryolite is also a powerful flux and opacifier in glazes for special purpose bricks.

Used as a mineralizer or flux, Cryolite promotes denser structures and lowers maturing temperatures in clay tiles and bricks.

Cullet

Broken or powdered glass. Can be used in refractories to form an intermediate ceramic bond between where organic binders burn out and before high temperature binders begin to develop ceramic bonds.

Can be used in engobes or "sands" applied as facing treatments to brick and in this use the relatively low melting points serve to bind the coating to the body.

Deflocculant

Any substance which when added to a mixture of clays and water, will cause the mass to become more fluid is called a deflocculating agent. Or, more simply, deflocculant.

Deflocculants may consist of hydroxides of monovalent cations (such as $Na+$, $K+$, or NH_4+) or salts of these cations that hydrolyze to a base (Na_2CO_3 or sodium silicate). Or they may be organic colloids such as pyrogallic acid, tannic acid, humic acid or alkali salts of these materials.

Certain clays contain varying amounts and variable sorts of organic matter which can react with soda ash or caustic soda to form highly effective deflocculants. Variation in slip quality is often traceable to differences in the quantity of organic deflocculant produced from batch to batch, either because of organic variation or processing differences.

Colloidal silica is a potent "protective colloid" and for this reason the higher SiO_2 sodium silicates are more effective as deflocculants for a given Na_2O content than those lower in SiO_2.

Some nonionic colloids, notably gums and glues, can be used to disperse clays in presence of water. Starch is an especially effective deflocculant.

The sodium salts of the polyphosphate glasses are extremely efficient deflocculants and constitute a special case because they can produce very fluid slips at relatively low pH (under 5.0) and high solids (upwards of 70%).

Since deflocculants liquefy, several advantages are evident. Less water is needed to produce a given plasticity and flow. Less horse power is needed to extrude the clay. The body is denser as a result of less water content.

The deflocculant may be a flux and lower the maturing temperature of the clay.

Sodium silicate is a very important deflocculant in plastic refractories because it can develop plasticity without the addition of too much water. Also, sodium silicate dries very hard and assists the ball clay in developing the hardness necessary for plastic refractories, ramming mixes and castables. It probably is one of the chief ingredients in this flexible type of refractory.

Sodium silicate has been used in many instances in stiff mud extruding. Besides bringing out the good properties of a deflocculant, sodium silicate also has a certain binder quality which aids in making good clay products.

The use of sodium silicate with the make-up water and dry press mixes assists in binding the dry press body, besides increasing flowability in the die and good packing.

Dextrin

Used as a binder and plasticizer for clay products, dextrin is derived from starch by treating with acid while being heated. (See starch and binders.)

Diatomaceous Earth

Diatomaceous silica, diatomite, Kieselguhr, is a highly siliceous mineral derived from skeletons of microscopic organisms. It is mined extensively in California and Nevada. Desirable features of material are its closed cells and high porosity which give a low density and a low thermal conductivity. Fusion point is 1715°C. Density is .8 to 1.2. Occurrence is widespread.

Insulating brick are made of this material by three methods. One type of brick is cut directly from the deposit and used in temperatures up to 1,500°F without shrinking. Where high temperatures are experienced, the brick cut from the deposit are pressed from the dust and prefired from 1,800 to 1,950°F to shrink them. Fired over 1,950 the brick develops spalling tendencies. To avoid the objectionable cristobalite form of SiO_2, which causes spalling, the brick is fired to 2,500°. To this brick is added 1 to 3% lime as a catalytic agent, and the brick is called tridymite brick. Grog, spar and clay are also included in the formula.

Dolomite

$CaMg(CO_3)_2$. Dolomite is a rock intermediate in composition between limestone and magnesite. It has a specific gravity of 2.9 and hardness of 3.5-4.0. The true material is composed of 56% calcium carbonate and 44% magnesium carbonate. There are, however, other materials containing appreciable amounts of magnesium carbonate, but less than the 44% present in pure dolomite, these are commonly called limestones and are used in the ceramic industry.

In the raw state, dolomite may be light buff, pink, yellow to brown and gray to blue. Its physical structure may be either crystalline or amorphous. When fired, dolomite is white; it decomposes to magnesia and calcium carbonate at 1,350-1,450°F. At about 1,650°F, all CO_2 is expelled, and the material burns to dolomite lime ($CaO : MgO$). In the presence of lower melting fluxes of acid character, it frequently decomposes at still lower temperatures.

Commercial deposits of dolomite are well scattered with important ones being located in Ohio, New York, Connecticut, California, Pennsylvania, Missouri, Texas and Kansas.

In general, dolomite may be substituted for nearly any other type of lime flux in glazes when other batch constituents are properly compensated. In ceramic bodies it promotes a glassy bond reacting with feldspar, flint and clay in the range of Cone 1 to 12 to form a lime glass. This property is of particular value in promoting the maturing speed, especially under rapid firing schedules.

The amount to be used varies with the vitrification desired and the firing temperatures, but the range of ½ to 8%, based on dry body weight, covers most vitreous and semivitreous bodies. Frequently a reduction in feldspar, with compensating increase in flint, seems to be possible. When dolomite is used to replace whiting, the safe firing range is widened by 1 or 2 cones. In combination with other fluxes, dolomite is effective as low as Cone 03-04 and is in use as an auxiliary in those clays which carry variable amounts of alkaline earths. In such bodies, it acts as a stabilizing flux and tends to widen as well as lower the firing range.

Electrolyte

For ceramic applications, an electrolyte is an acidic, basic or neutral substance capable of dissociating partly or completely into ions in water solution. The basic electrolytes promote deflocculation whereas the acidic and neutral compounds usually bring about flocculation of clay-water dispersions.

Thus the type and amount of electrolyte can be used to govern the character of ceramic slips and bodies and thus influence plasticity, casting qualities, dry properties such as strength and fire properties. Examples of basic electrolytes are caustic soda, soda ash and sodium silicate. Acidic electrolytes may be acids such as HCl or acid salts such as NH_4Cl. The neutral electrolytes are salts of strong acids and strong bases such as NaCl. (See Deflocculants.)

Engobe

An engobe is a clay or mixture of clays, fluxes and nonplastics which can be applied to a clay body such as a brick or tile which can be tinted any color and will cover small defects on the face of the body. Engobe can be used between the clay body and a glaze surface to mask the natural color of the body.

However, in structurals, engobes are of interest when used to color the ware and to change the appearance or texture of the unit. Many common clays can be used in the preparation of engobes in which case they should be finely ground or, if easily slacked, mixed with water and blended. All particles not passing an 80 mesh screen should be reground or discarded. To this base material, feldspar, calcium carbonate and flint are commonly added to affect shrinkage, softening point and refractoriness of the engobe.

If local clays are not available that have compatible colors, which usually means light firing shades of buff or white, commercial ball and china (kaolin) clays can be used for the base material. Due to the comparative high purity of these clays, preparation is simplified but they might not be as easy to "fit" to the body as local clay.

Engobes are sintered or vitrified to a greater or lesser degree and differ from glazes in that the glassy phase is not strongly developed. Other modifiers that can be used are magnesium carbonate, borium carbonate, bone ash, zinc oxide, mica and lead oxide.

Engobes can be applied in a number of ways to bodies in the green or dried condition or even to a prefired body if that should for some reason be desired. Engobes may be applied by dipping, rolling, brushing or spraying.

Any of the common coloring oxides can be used to affect the fired color of the engobe, or local occurring materials can be used. Colors that do not contrast with the body color are preferred as small chips and imperfections are not as critical. The pallet of colors is practically unlimited, however.

Engobes do not stick badly in the kiln if properly formulated. Coarse sand can be mixed with them for fine architectural effects. They can be applied over practically any texture.

Epsom Salts. (See Magnesium Sulfate)

Feldspar

Feldspar is the most common mineral in the crystalline rocks. The feldspars form a group of which the principal types are orthoclase, microcline, albite and anorthite. These are aluminum silicates of potassium, sodium and calcium. Chief commercial sources of supply are North Carolina, South Dakota, Colorado, Maine, Virginia, Arizona and Connecticut.

Free quartz acts as a dilutent in feldspar and decreases the fluxing power. In unburned ceramic bodies, feldspar acts as an anti-plastic the same as sand does. Soda feldspar and quartz mixtures deform much more rapidly after deformation begins than do the potash feldspars or any of their mixture with quartz. High soda content, in general, indicates low deformation or low fusion temperature. The fusion point of a feldspar depends upon the alkalis present and becomes lower as the soda content increases and the potassium oxide content decreases. Some spars fuse as low as cone 4; others as high as cone 10 but the general average fuse at cone 8 to 9.

Feldspar is frequently said to be a universal flux used in all types of ceramic bodies.

Feldspar is widely used in glazes for structural clay products including facing tile, ceramic sewer

pipe glazes, terra cotta, etc. Its role in glazes is to provide fluxing action and it should be finely ground for this purpose. Generally a material that is ground to at least 98% finer than 200 Mesh is purchased and this, of course, is subjected to additional grinding with other glaze ingredients in ball mills prior to use. Both potash and soda feldspars are used in glazes but preference in most instances is for a potash type. Potash spar is desirable because it dissolves the silica more readily and makes a more durable glaze. Soda feldspar has an advantage of making a smoother fired glaze.

In recent years specialty face brick and tile in a wide range of pastel colors and white and black have been produced commercially using potash feldspar as a major ingredient in the ware itself. In this application the finely ground feldspar from Custer, South Dakota, acts as a major flux which allows earlier maturing of the clay body. A secondary role is to act as an extender for the expensive mineral oxides used as coloring agents in these brick.

Several face brick manufacturers have developed "sand coatings" or "granular coatings" for red burning brick. These coatings impart attractive color and texture to red burning ware. Feldspar is a major ingredient in many of them. It acts as an extender for the expensive coloring oxides. However, its major function is as a flux to form a fired bond between the coating and the brick itself. Soda feldspar is preferred due to its lower fusability.

Fine ground feldspar rejects have been used in some buff and red burning face brick to provide greater vitrification and lower fired absorption at lower temperatures. In experimental work done at Clemson College, additions of low cost feldspathic brick flux in amounts from 2.5 to 10% resulted in equivalent porosity for the brick with the additive from three to five cones lower. Additions of from 5 to 10% of brick flux prepared from feldspathic waste material improved the fired modulus of rupture of the structural clay product body by 10 to 25%.

The work of Clemson College by the Dept. of Ceramic Engineering showed that the fineness of the flux which is added is at least as important as the chemical composition. In the case of the feldspars studied at Clemson, 200 Mesh feldspar from Kona, North Carolina, and 200 Mesh feldspar from Bedford, Virginia, gave more outstanding results than did coarser grinds of the same materials.

Flint

SiO_2. A black, gray, or brown cryptocrystalline variety of quartz. It commonly occurs as nodules, either with calcareous coating in clay or as coarse pebbles along a seashore where the coatings have been removed by attrition. The dark color of flint is probably due to carbonaceous matter. The mineral breaks with a characteristic conchoidal fracture, is readily soluble in alkaline solution at 200°C, and is soluble in fused feldspar. Flint pebbles are quarried along the coasts of Denmark, France, and England. It should be clearly understood that in the United States ceramists often employ the term flint to include other siliceous minerals in addition to true flint; "sand flint," "rock flint," tripoli flint," generally called potter's flint, are various types of ground sandstone and quartzite, not true flint, but utilized in exactly the same way.

Fluorspar

Fluorspar is a name most accurately applied to nonmetallic mineral aggregates which contain a large amount of calcium fluoride, CaF_2. Calcium fluoride, in fluorspar, constitutes the mineral, fluorite, containing almost equal percentages by weight of the elements, calcium and fluorine. The mineral fluorite is a glasslike substance, translucent to transparent, even opaque at times, and ranging in color from colorless to bluish through varying shades of violet, purple, green, and yellow.

As found naturally, it is crystallized into well-formed cubical shapes and it cleaves readily into octahedra. Mined as fluorspar, it is commonly associated with many different accessory minerals and must be processed by various types of beneficiation techniques. Most commercial domestic fluorspar is mined in Kentucky and Illinois.

Fluorspar has a long history of utilization as an active fluxing agent in ceramic wares, especially in glasses and enamels, as well as in glazes and porcelain bodies. These uses demand a higher purity fluorspar containing upwards of 90% of the mineral, fluorite. When used as an additive to heavy clay products, the purity is secondary in importance to the fineness of the fluorspar.

In its most common use as an additive to light firing brick, tile, etc., Ceramic No. 2 grade fluorspar is of sufficient purity. A very fine-grained fluorspar, essentially finer than 325 mesh, is marketed under the name "Superfine." Also available is a fluorspar treated to improve its wetting properties. The properties of fineness and wettability of this additive are desirable because, unlike some efflorescence deterrents, fluorspar is quite insoluble. Again, for this reason, the fluorspar should be added early in the clay preparation technique to insure intimacy of mixing with the clay. The admixture is best done in the secondary grinding stage, for example, at the dry pan.

Incomplete mixing will result in local concentration of this strong flux within the ware giving rise to heterogeneous maturation upon firing. Local aggregation of the flux can cause spalling of the ware due to differential maturity within a single unit.

Fluorspar has been found to be the most economical, most effective, and most easily usable additive for the prevention of green efflorescence in light firing ware. Its effect is twofold. Through its fluxing action, it promotes earlier vitrification and consequent lower porosity in firing, thus reducing subsequent movement of soluble vanadium salts to the surface of the ware.

Secondly, through reaction with compounds of vanadium, insoluble compounds are produced, or, in some instances, volatile phases result which are driven off during firing. In each of these events, the result is the successful prevention of green colored efflorescences.

The amount of the additive necessary can only be determined through trial testing. On the average, about 1 per cent by weight is normally sufficient for control, although 2% to 3% may be required in certain difficult cases.

In addition to its ability to curb green efflorescence, fluorspar has been noted: to reduce white efflorescence due to soluble sulfates; to deter colored efflorescences due to molybdenum; and to prevent brown staining caused by manganese compounds. In all instances of its use as an additive, even firing, through good temperature control techniques, is essential to prevent over-firing or undesired deeper colors of light wares.

Flux

A flux in ceramics as well as other compounds is a material which lowers the fusion point of any mixture in which it is present.

For instance in certain castable plastic and ramming refractories, glass is used as a flux to melt the particles of clay together at a low temperature and form a hydrofractory in place earlier.

Certain materials as feldspar, volcanic ash, nepheline syenite will act as a flux on high temperature firing clays to lower their temperatures of maturing in the manufacture of brick and tile.

Certainly fluxes are very important in developing glazes on brick and tile. Lead is generally the chief one of these fluxes. Lead silicate, a commercially prepared combination of lead and silica, is used for fluxing glazed materials. Boric acid, borax, soda ash are some of the other materials used for fluxing glazes.

Frit

A glassy material produced by fusing a mixture of some or all of the constituents of a glaze or enamel so as to render insoluble any soluble materials present, and also to insure greater homogeneity, to lower the melting point, and to render toxic compounds non-poisonous.

To qualify as frit, the glassy material must be in a granular form, for the word derives from "Fritting," the process of quenching molten glass.

In glaze work it is often necessary to use low-fire leadless glazes, and here the frit plays an important part. In most low-fired glazes, soluble materials are necessarily used, and fritting renders them insoluble. A fritted glaze of the low temperature type is said to be more stable than a low temperature raw glaze.

Glazes

Generally homogeneous, thin silicate mixtures fused on the surface of a clay body. They are glasses in their physical and chemical nature, hard, slightly or completely insoluble excepting in strong acids or bases, impermeable to gases and liquids. Like glasses they are not definite chemical compounds but complex mixtures which sometimes are described as undercooled solutions since many of their properties are analogous to those observed in ordinary solutions.

Glazes are more or less lustrous. Generally the surface is highly reflective or glossy, but the matt glaze has a surface which has been compared, quite accurately, with the appearance of a glace kid, and all gradations of glossiness or mattness may be observed.

Glazes may be colored or colorless, transparent, translucent, or opaque. Whatever the appearance, the glaze or similar coating is used on clawares to make the ware impermeable to liquids and gases and/or to provide a decorative effect. Designing of glazes to "fit" any given body is a complex problem involving variables of temperature maturity, expansion under temperature, viscosity, toxicity and color.

Glaze Stain

Glaze stains are prepared calcined ceramic pigments, to be mixed with a glaze before it is applied to the body to give a uniform color throughout the glaze layer. Most glaze stains function as pigments. Some remain as precipitates, others going in solution in the fired glass. The color range of glaze stains is very wide at the lower temperatures but at Cone 8 or higher many glaze stains become unstable to some degree and the obtainable color range is much more restricted.

Glue

An impure form of gelatine which can be used as a binder both for glazes and for bodies. (See Binders.)

Grog

Generally any clay-like material that has been fired to a temperature where the characteristic plasticity is destroyed. Used in structural production it serves to eliminate laminations, makes drying and firing faster and with less shrinkage.

It is much used in refractories, terra cotta and sewer pipe. While strictly speaking grog includes calcined clay, generally the latter is excluded from the classification. Grog can be made from cull material or pieces especially made and fired for this use. Grinding is expensive due to the high wearing rates and mixes containing grog can be very abrasive. This tends to retard its use but excellent results can be expected when the added costs are not prohibitive.

Gypsum. (See Plaster of Paris)

Glucose

A vegetable sugar that can be used as a binder in clay bodies. It is a Carbon-Hydrogen compound that exhibits similar properties as starch and dextrine. (See Binders.)

Iron Chromate

$FeCrO_4$. Mol. wt. 171.85. Ferrous chromate is used with cobalt oxide in under-glaze blacks, and also makes good black stains which may be added to a body. Iron chromate is also used to color engobes and has been a constituent of Cone 6 cherry brown and also dark pink overglaze polychrome. Brown and black colors in glass are also produced by iron chromate. Used as pigment for gray body stains.

Iron Oxides

FeO, ferrous oxide; Fe_2O_3, ferric oxide, hematite; and Fe_3O_4, ferrous-ferric oxide, magnetite. The oxides of iron produce dark brown colors generally. Very finely divided iron oxide is responsible for the red color common in clay products, but larger particles give brown or black slag spots which may detract from appearance.

For this reason, much expense and processing is incurred in the removal of iron oxide from all types of ceramic raw materials, sand, feldspar, nepheline syenite and practically all other white-burning minerals. Some work has been done on the removal of iron from clays by complicated procedures but none of these has as yet reached commercial production.

Heat treatment can affect the final color of brick containing even small percentages of iron. Mainly, these techniques are known as "flashing" and consist of manipulating the oxygen content of the atmosphere at certain critical temperatures.

Iron acts as a fluxing agent and small quantities can lower P.C.E. drastically and for this reason must be kept out of refractory products.

Clay Modifiers· Body Conditioners

Coloring Agents • Deflocculants • Binders • Fluxes

Kaolin

(China Clay) ($Al_2O_3 : 2SiO_2 : 2H_2O$.) This material fires to a white color and has a cone equivalent of 34-35.

The name, kaolin, comes from the two Chinese words Kao-ling, meaning "high ridge," originally a local term to describe the region from which the kaolin or "china clay" was obtained. The term was originally used in this country to refer to certain residual clays of a white or nearly white-burning character. In recent years, however, it has been stretched to cover certain white sedimentary clays like those obtained in South Carolina and Georgia. The present terminology differentiates between the two types of deposits by designating as primary or residual kaolins those white burning clays formed by the weathering, in place, of feldspathic rocks, pegmatite dikes, granites, and the like found in the location of the parent rock. Secondary or sedimentary kaolins are those that were formed by weather, then carried by water and redeposited in another area. Thus the secondary kaolins of South Carolina and Georgia were deposited in the sea, in an area later uplifted to form the Atlantic Coastal Plain.

Most of the domestic supply of residual kaolin is obtained from western North Carolina, and most of the sedimentary clay comes from Georgia and South Carolina. Many deposits of china clay are found in England and this material has for many years been a serious competitor of the domestic product. The American clay usually has finer grain and greater plasticity, therefore greater strength.

S. C. and Ga. china clay has been used throughout industry for years. It is one of the most uniform kaolins to be found. Generally speaking, there are two types of Georgia kaolin, one imparting unusually high strength and plasticity used where a high degree of workability is required. The other type, generally the fractionated controlled particle size clay, behaves well, dries uniformly, and reduces cracking of ware.

In 1950, 1,751,000 tons of domestic kaolins, valued at almost $24,000,000, were consumed in the U.S. Of this total it is estimated that the refractory industry uses some 9 percent.

When used as part of a refractory mix, the kaolin is sometimes supplemented with ball clays which improve the plasticity of the mix and strength. These improvements in handling characteristics are made with a sacrifice of refractoriness otherwise expected from kaolin used alone.

In many brick plants, local kaolin deposits are worked and the crude kaolin mixed with other clays or shale, to secure pastel colors. An additional effect of such mixtures is to raise the maturing temperature of the body and the range in which a satisfactory product can be produced. In the production of clay pipe, the increase of maturing temperature sometimes improves the glazing operation to a marked extent.

Kaolin can be used as a clay source in the preparation of engobes and slips. The extreme whiteness of the kaolin coupled with its high refractoriness allows the preparation of pastel colors maturing in a wide range of temperatures. In these uses, the low shrinkages during drying and firing are qualities that should not be ignored.

Kaolin, Florida

(Ball Kaolin). The kaolin deposits of Florida are found in the north central part of the state. They are mixed with white silica sand and pebbles. These deposits will average about 15% to 20% clay. When the sand and pebbles have been washed out, there is only 1½% to 2% clay solids in the stream going to the thickening vats. This provides a tremendous averaging effect and also results in a clay of high purity and cleanliness.

Florida kaolin has unusual physical properties not ordinarily associated with most kaolins. It can be described as a ball-kaolin. It has the refractoriness and high white fire color of kaolin coupled with the strength, workability and particle size distribution of a ball clay. This type kaolin has a greasy property that, together with a very fine particle size, gives it a very high degree of workability. It is very clean and uniform.

Florida kaolin is used in jiggering and extrusion processes where a high degree of workability is required. Excellent flowing properties make it very useful in dust press operation. It is used in bodies where high strength is required. It has excellent suspending power and is widely used in glazes. The low titanium content makes it desirable in colored bodies and colored glazes where greater purity of color in pastel shades is desired. Small percentages in casting bodies are helpful, acting as buffer for the electrolyte.

Kaolinite. (See Kaolin)

Lead Carbonate

(White lead). $PbCO_3 \cdot Pb(OH)_2$. Mol. wt. 776, sp. gr. 6.7, and decomposes at 400°C. Insoluble in water, slightly soluble in aqueous CO_2 and soluble in acid. It is a white powder, which is prepared by treating lead with acetic acid and carbon dioxide. The carbon dioxide is often generated by the fermentation of waste tanbark, which material sometimes gives a pink stain to the lead carbonate.

Modern methods of producing white lead use purified carbon dioxide produced by controlled burning of fuel and avoid the tanbark contaminations.

Lead carbonate is an important constituent of glazes. It is preferred by whiteware, earthenware and vitreous tile manufacturers to other lead compounds. Smaller amounts are used in enamels and glasses. Lead carbonate has advantageous purity, particle size, water dispersive and suspensive qualities. Fine size particles cause better suspension in raw glazes and quicker and more homogeneous fusions in frits. Due to high specific gravity of the oxides, difficulty in maintaining suspensions may be caused. The release of CO_2 and H_2O gas from lead carbonate under heat gives a degree of mechanical mixing and leaves the lead in a condition favorable to rapid chemical action which chemists describe as nascent. This is probably the cause for lead carbonate showing more rapid fusion.

Lead Oxide

Two types of lead oxide are used in ceramics, litharge or lead monoxide and red lead. Litharge, PbO has a mol. wt. of 223, sp. gr. of 9.3-9.5 and a melting point of 888°C. Insoluble in water but soluble in alkalies, certain acids and some chloride solutions. Red lead Pb_3O_4 has a mol. wt. of 686 and sp. gr. of 9-9.2 and it decomposes between 500° and 530°C. It is insoluble in water and is decomposed in some acids, leaving insoluble lead peroxide.

Lead and its oxides and other compounds are derived from the mineral galena which is mined in Kansas, Missouri, Idaho, Utah, Oklahoma, Mexico and foreign locations.

Lead has many advantages as a glaze ingredient, which results in its continued use in spite of the hazard to the worker. The superiority of lead glazes lies in their brilliance, lustre and smoothness, which are due to their lower fusion point and viscosity. Lead glazes are resistant to water solubility and chipping, and have few faults in texture and bond. They have high mobility, refractivity and elasticity, and are softer than leadless glazes. Lead glazes are said to be more "fool proof" in the plant, since errors in processing and composition affect the properties of the finished ware to a lesser degree.

All investigators agree that the use of fritted glazes, in which all of the lead is fritted, has important health advantages. In this way the raw lead is converted into relatively harmless lead silicates which are much less soluble in dilute acids or the gastric juices. Lead silicates are more slowly absorbed after entering the respiratory system, and can be eliminated with less lead absorption. Of the lead silicates, the bisilicate is much less soluble than the ortho-silicate or the mono-silicate. When dustless lead silicate is used in place of lead oxide, the lead hazard is practically nonexistent.

Lead Silicate

(Lead bisilicate or lead monosilicate.) Two types of fritted lead silicates are available for use in raw glazes, and enamels. (A) A 15% SiO_2, 85% PbO composition which is approximately the eutectic mixture of lead orthosilicate ($2PbO : SiO_2$) and lead metasilicate ($PbO : SiO_2$). It melts at 725°-775°, and is free from uncombined lead oxides and silica. This material is sometimes called lead mono-silicate. This is not strictly accurate since lead monosilicate would more properly refer to the lead metasilicate composition ($PbO : SiO_2$). It is used, however, to distinguish the basic lead silicate from lead bisilicate. (B) A composition of 65% PbO, 34% SiO_2 and 1% Al_2O_3. This material is commonly called lead bisilicate. Either of these materials offers a number of practical economies in plant production and allows the introduction of lead, with its consequent benefits, in an easily handled, dustless and safer form. The mechanical and volatilization losses of lead are thereby reduced to the minimum. The monosilicate can be used competitively from a cost standpoint to replace lead carbonate, red lead or litharge.

Lead Silicate, Hydrous

"$Pb\ SiO_3$—$Pb(OH)_2$, mol. wt. 807, sp. gr. 5.8-6.5. This material has been put on the market as an alternate or replacement for basic carbonate white lead where the evolution of CO_2 from the carbonate is undesirable. It is a fine particle size powder of high purity and is prepared by milling and hydrating "lead monosilicate" under controlled conditions. It has been found useful as a mill base addition because of its freedom from gassing; good dispersion; and excellent suspension qualities.

A glaze can be made for sewer pipe using lead silicate and up to 40% of the native clay as a base in addition to other glaze constituents. This glaze, while more expensive than normal salt glazing, produces higher strengths and more attractive glazes.

Lepidolite

Commonly called "lithium mica," this compound is a lithium-potassium-aluminum fluorsilicate: $LiF : KF\ Al_2O_3 : 3SiO_2$. The theoretical lithia content is 6% plus but actual samples run about 4% due to partial alteration of the mineral and partial replacement of lithia by soda and potash. It is found chiefly in California, Colorado, South Dakota, New Mexico, Rhodesia and Southwest Africa.

Lepidolite may be used to brighten most glazes. It is added with flint at the expense of feldspar on a balanced alumina-silica ratio basis. High grade lepidolite is available in large quantities.

Lignin, Lignin Extract. (See Binders)

Lime

(Calcium oxide, whiting) CaO. Mol. wt. 56 and sp. gr. 3.4. Lime as CaO is not found in nature. Calcium carbonate, which is the chief source of lime, is found in the form of the mineral, calcite. Impure calcite occurs as rock limestone in large quantities in many parts of the world. Limestone may vary from pure calcium carbonate to pure dolomite, $CaMg(CO_3)_2$. Commercial lime may contain as high as 45% magnesia and such impurities as silica, iron oxide and alumina. Commercial limes are classified according to their relative content of CaO and MgO, as follows:

High calcium lime—less than 5% magnesia.
Magnesia lime—5-25% magnesia
Dolomitic lime—25-45% magnesia.

A lime carrying less than 5% total of silica, alumina iron and so forth is a rich lime. Use of the term lime, in ceramics, generally infers some ground limestone sold as whiting.

Limestone occurs in many parts of the world, some of the purest being found near St. Louis, Mo., and in Kentucky. As whiting, lime is found in England as a defined chalk, such as the chalk pits

of Dover. As dolomite it is found in various parts of the world and in this country the best known deposits are in northern Ohio. Wollastonite is a form of calcium silicate and at times it is said to constitute the chief mineral of the rock mass. This type of limestone is found in California, in the Black Forest of Germany and in France.

A number of terms are in general use for the different varieties of limestone based on differences of origin, texture, composition and so forth. The more important are as follows:

Marble is a limestone which is more or less distinctly crystalline. A marl is a loosely cemented mass of lime carbonate with clay and usually found in lake basins. Oolitic limestones are so called because of their resemblance to a mass of fish roe and are made up of small rounded grains of pure lime carbonate. Chalk is a fine grained limestone composed of finely divided calcium carbonate from shells. Argillaceous limestones are those in which silica is present in combination with alumina.

It may be said, regardless of the impurities that are found in limestone, that lime is in all cases practically the only base found in a pure theoretical limestone. In the dolomitic lime the base is some value between magnesium and calcium in certain definite proportions very close to 56 of calcium carbonate and 44 of magnesium carbonate.

In a leadless type of matt glaze, calcium in combination with chrome stain produces a fine green. Calcium and zinc produce a pinkish to brownish shade, while calcium and barium produce a dark green. Calcium and magnesium produce a brownish shade, and calcium and lead produce a fine bright green.

In the regular type of bristol glaze with a low feldspar content, that is, lower than .4 equivalent, maximum gloss is obtained when the ratio of CaO to ZnO is less than 1:1, while with high feldspar the ratio of calcium to zinc must be higher, that is, at least 3:1.

Lime is used in the production of silica brick. It is added either dry to the mixer or suspended in the water added to the batch. It acts to bond the nonplastic quartz grains together before firing and, more importantly, exerts an important influence on the conversion of quartz to the higher crystalline forms of silica.

The material, finely ground, can be added to red firing clays used for brick or tile. Used in this manner the effect of iron as a coloring agent can be minimized or overcome, resulting in a light pink or yellow and dirty buff. Flashing procedures will affect the final color. However, the safe firing range will be reduced at the same time and the maximum temperature that the ware will stand is also reduced. Over firing will result in sudden and catastrophic vitrification.

Lime in the form of nodules of any great size occurring in clays will seriously impair the economic utilization of that clay. Such stones, if burnt in the brick, will, when exposed to the air, hydrate and the increase in size will fracture the exterior face of the unit. When occurring as a strata of limestone in a pit the entire strata can be picked out. Lime occurring as scattered stone in alluvial deposits can be removed with conical rolls if of large size and the smaller stones can be crushed to small sizes by running all of the material through smooth rolls. The harmful effects are minimized when the size of the lime is reduced.

Limestone. (See Lime)

Limonite

(Brown iron ore.) $2Fe_2O_3 \cdot 3H_2O$. An impure hydrous ferric oxide; probably actually a group of substances of variable composition and colloidal in nature. Impurities are silica clay, manganese oxide and organic matter. The water content is colloidal rather than combined and, though variable, averages about 15%. Sp. gr. 3.4-4.0 and hardness 1.0-5.5. Limonite gives yellow and orange coloring to clays, though it is sometimes obscured by organic matter present. On heating to about 500°C, limonite is decomposed to red ferric oxide. Limonite automatically colors clay bodies in which it occurs. Occasionally the mineral is intentionally introduced to get iron oxide colors. Blue shale deposits often leach to a characteristic yellow on exposure to the elements and this color change is associated with the change of other iron compounds to limonite.

Litharge. (See Lead Oxide)

Magnesium Carbonate

Magnesite

(Magnesite) $MgCO_3$. The mineral magnesite has a sp. gr. of 2.9-3.1 and a hardness of 3.5-4.5. Chemically pure magnesium carbonate has a mol. wt. of 84.3 and sp. gr. of 3.0. It loses its carbon dioxide at 900°C, is slightly soluble in water and soluble in acids. Magnesite is quarried in Washington, California, Russia, Austria, Greece and Czechoslovakia. Magnesium carbonate is also produced from sea-water in California, on the Gulf Coast and recovered from brines in Michigan.

It is the major constituent of a group of refractory products, basic refractories, that are growing rapidly in importance and are used in cement kilns and the furnaces of the metal-producing industries. When used for this purpose, the magnesium carbonate is "dead burned" in rotary kilns to produce a hard dense pebble of varying size. This intermediate form is crushed and the particles graded to provide a mixture of particles according to a designed standard. The magnesium carbonate is then mixed with other ingredients including organic binders in batch mixers and brick are formed by the dry press method. Such brick are available as chemically bonded brick or as fired ware.

The chemically bonded brick are burned in service. An interesting phase of their production is the use of metal covers for a significant amount of them. Metal clad brick are reserved for areas of intense conditions. While more expensive than either clay or silica refractories, the added life and higher operation temperatures attainable with basic refractories seems to indicate the continued expansion of the use of this material. An important number of chrome-magnesite brick are being manufactured in which the magnesite is used with varying proportions of chrome ore.

In glazes, magnesium carbonate acts as a refractory up to a relatively high temperature when it becomes an active flux. The formation of magnesium silicate in glazes develops an elastic glaze and at the same time develops glazes with rather low coefficients of expansion. Very often magnesium carbonate is used to check the fluidity of a glaze. This is a desirable property when dealing with crystalline glazes. Magnesium carbonate also seems to improve adherence.

Magnesium Sulfate

(Epsom Salts). $MgSO_4 \cdot 7H_2O$. Mol. wt. 246.5. Soluble in hot or cold water. Magnesium sulfate occurs as the mineral epsomite; it is found in British Columbia and in Washington, and is found in brines in Michigan. This material may also be produced by the action of sulfuric acid on magnesite, dolomite or other magnesium rocks.

The most important ceramic use of magnesium sulfate is for setting up enamels. The proper amount of magnesium sulfate enables an enamel to be used for a long time without balling up, and it prevents the enamel from running on a piece of ware. Too much of it produces a dull finish and possible crazing. Further, magnesium sulfate in the slip causes rust on any iron containers.

The effect of magnesium sulfate addition has been noted on dipping slips and in one case the use of 3 cc of magnesium sulfate per quart resulted in a heavy application with good draining.

When used to set up or thicken a glaze or slip, it must be used with caution as the ideal amount is quite critical. Besides reducing running of a glaze from a coated surface, it serves to increase the storage life.

Magnesium sulfate is one of the causes of "dryer house scum" appearing on structural ware. Clays containing small quantities accumulate a thin coating of the salt on the surface of the ware when the water of plasticity is evaporated in the drying process. During firing, the soluble salt is dissociated, the SO_3 being driven off into the atmosphere and the magnesium forming complicated calcium-magnesium-silica compounds that are insoluble and show as white or gray marks on the exposed parts of the brick.

Control of this type of scumming is usually done with barium carbonate which precipitates the soluble compounds to form insoluble compounds thus eliminating the migration of the scum causing material to the face of the brick during drying.

Other control methods used have included covering the face of brick with paper which was then burned off in firing and the reduction of the water of plasticity.

Magnesium sulfate can be added to clay to produce the characteristic white marks of "dryer house scum" if there is a market demand for such material. Application can be made with feeders or dosing each load of material as it is used. Amounts required to produce any degree of scumming very with clay and the conditions but small additions on the order of fractions of 1% have proven sufficient in some cases.

Magnetite. (See Iron Oxide)

Manganese Oxide

MnO_2. Mol. wt. 87 and sp. gr. 5. It is converted into MnO at 535°C, is insoluble in water and nitric acid and soluble in hydrochloric acid. It occurs in nature as the black mineral, pyrolusite, which is mined in Russia, Gold Coast, India, South Africa and in small quantities in several of the United States, including Tennessee, Montana and Virginia.

Manganese dioxide is much used in the face brick industry to develop gray effects in the body of buff firing brick. When used as a body stain, effect depends on the grain size of the manganese as well as the amount used.

Mesh sizes of 20, 40 and 80 are often used for speckling effect while air-floated manganese develops uniform gray tones. When used in larger proportions, dead black brick can be produced. When used as an additive to red burning brick, the effect is to make a rich red color, depending on the amount used.

In larger grain sizes, manganese can be added to glaze to develop texture effects as well as large black spots contrasting with the color of the glaze. Some producers use fine manganese to break up the monotone of glazes. In this service it tends to mask slight imperfections which would otherwise detract from the appearance of the units and will perhaps lower the rejection rate at the sorting and grading station.

Used as a color constituent it can produce pinks and browns as well as purples, depending on its associated compounds. It is quite sensitive to minute changes in firing conditions.

Mica

A general term used for a large group of materials making up a major division of clay minerals. Generally regarded as impurities in finer clays and subject to removal by washing, illites or mica may in structural clays be the major clay-like mineral present. It has characteristic endothermic peaks by which the presence of the mineral can be determined.

More specifically mica is used for the material that splits into characteristic sheets of considerable size and is used in industry as insulators and dielectrics.

A form of considerable interest to the structural field and to refractories is vermiculite, a form of mica that on rapid heating expands 16 times accordian-fashion to form a light and inert material suitable for inclusion in lightweight structural bodies and as a grog in refractories or as an aggregate for the production of lightweight casting refractory concretes.

Molasses

A complex organic material derived from the refining of sugar from sugar cane. It has been used as a binder in the preparation of silica, magnesite and carbide refractories. In this use molasses has two effects. One is to increase the plasticity of the body during the forming operations reducing losses due to handling; when dry the body containing small additions exhibits much greater strengths and during firing the additive burns away without affecting the composition of the body.

Mullite

$3Al_2O_3 \cdot 2SiO_2$. Sp. gr. of 3.16. It occurs in nearly all fired ceramic products containing alumina and silica but is seldom introduced as such, except as calcined kyanite which is converted into mullite in calcination. Mullite is rare in nature, one locality being the Isle of Mull, Scotland, where argillaceous sediments have been fused by igneous intrusion. The compound was formerly thought to be synthetic sillimanite, which name still persists in some quarters. Mullite is very refractory, breaking up into corundum and liquid silica at 1,810°C.

In the manufacture of refractories, the desirable mullite is formed from the chemically similar minerals, andalusite, kyanite and dumortierite, which decompose into mullite and silica at Cone 13, Cone 12, and Cone 6, respectively. To break up sillimanite in the same way, Cone 20 is required.

Mullite bodies show a uniform rate of thermal expansion and are resistant to spalling and deformation under load. Their strength is due to the

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interlocking of long, needle-like crystals. Some authorities recently stated that to get long crystals there must be present impurities which will promote their growth, therefore a mullite body with short interlocking crystals is more stable at high temperatures.

Nepheline Syenite

A holocrystalline granular igneous rock made up of nepheline ($K_2O : 3Na_2O : 4Al_2O_3 : 9SiO_2$), potash feldspar (microcline), soda feldspar (albite), and such minor accessory minerals as mica, hornblende and magnetite. It is found in New Jersey, New Hampshire, Virginia, Montana, Canada, India, Russia. It resembles granite in texture but contains no free quartz. An analysis of the commercial ceramic nepheline syenite from Blue Mountain, Ontario, is:

Loss on ignition	.3%
SiO_2	60.0
Al_2O_3	23.2
Fe_2O_3	.06
CaO	.3
MgO	Tr.
Na_2O	11.1
K_2O	5.0

This analysis represents the commercial material after removal of iron. The iron content of the original rock is in the range of 2 or 3%.

First quality nepheline syenite starts to sinter at cone 08 and has a PCE of about cone 7. There is a eutectic between soda feldspar and nepheline which is a factor in the wide sintering range of nepheline syenite.

In the past decade, nepheline syenite has found some application in glazes for structural clay products, including facing tile, terra cotta, ceramic glazes for sewer pipe, etc. In low temperature glazes where fritting is not done, nepheline syenite is especially helpful in promoting the maturing of the glaze due to its relatively low fusability.

Some high iron grades of nepheline syenite have been used for making sand face brick, imparting a textured, granular, decorative effect to the brick's surface.

The nepheline syenite is usually mixed with coloring oxides and some sand. Its primary role is to form a fired bond between the sand grains in the coating and the body of the brick. It also acts as an "extender" for the expensive mineral oxides.

Work done by Everhart at the Ohio State University Engineering Experiment Station showed that additions of 2.5 to 5% of nepheline syenite to the clay as a body flux gave acceptable absorptions and fired strengths that are obtained at substantially lower temperatures without accompanying reductions at the upper firing limit. This, of course, results in longer maturing ranges. At the same firing temperature sizable reductions in absorptions and increases in strength are secured.

A paper presented by Wilson and Koenig of the Ohio State University Engineering Experiment Station at the 59th Annual Meeting of the American Ceramic Society, Dallas, Texas, May 1957, reported on the use of nepheline syenite tailings in sewer pipe bodies. Their report dealt with minus 30 Mesh tailings from the high intensity magnetic separators used in preparing first quality nepheline syenite for use in glass and whiteware production. These tailings contain 2 to 3% Fe_2O_3 and are ground to a point where approximately 99% passes a 200 Mesh sieve. The authors reported that when fired to cone 02 and above, the additions of ground nepheline syenite tailings to fire clay and shale bodies provided lower absorptions, improved flexural strengths and longer maturing ranges.

The thermal expansions of a fire clay and shale sewer pipe body were significantly increased by additions of ground tailings—the effect was greater at lower cones than at the higher cones. The ground tailings also helped to reduce the free quartz content in the bodies.

When firing below cone 02 the additions of ground nepheline tailings to the clay and shale bodies affected the unfired properties thus acting in the role of a refractory grog.

The authors further reported that the commercial production of sewer pipe using a body containing 5% of the ground tailings and firing to cone 3 has confirmed the laboratory results regarding the lower absorption and increased flexural strength derived from the addition. A large reduction also was noted in the number of cracked pipe when the tailings were used. The reduction in the number of cracked pipe, according to the authors, may possibly be related to several factors, namely:

a. A slightly lower drying shrinkage and resultant drying strains owing to the non-plastic addition.

b. A reduction in the amount of free quartz present in the body owing to the absence of free quartz in the nepheline syenite, and

c. A reduction in the amount of free quartz in the body introduced from shale or clays as a result of the solution of the quartz by the additive (nepheline syenite) during firing.

Ochre

Natural occurring stains which are for the most part hydrated ferric oxides mixed with clay and/or sand in varying amounts. They can be used as coloring agents for engobes or "sands" applied to face brick and have in the past been used to color the "salt" coat applied to ware that resists salt glazing. In this technique fine, 60 mesh or less clay prepared from the native clay is mixed with ochre and applied to the surface to "catch" the salt glaze.

When ochres carry much manganese they grade into the umbers.

Opacifiers

Opacifiers are those materials used in glaze to produce an appearance usually called opaque, although they really possess translucency rather than opacity. Originally tin was the major material used to opacify glazes but more recent techniques make use of compounds of zirconium and titanium which provide similar results at less cost.

Orthoclase

$K_2O : Al_2O_3 : 6\ SiO_2$. A potash feldspar useful when the total quantity of sodium must be limited. (See Feldspar.)

Petalite

Lithium-aluminum silicate has the formula $Li_2O : Al_2O_3 : 8SiO_2$ and a density of 2.4. It contains 77.0% SiO_2, 17.5% Al_2O_3, 4.3% Li_2O and 0.5% other alkalies.

Petalite can be added up to 45% in semi-fritted glazes, resulting in a clear bright texture maturing at cone 02 up to cone 5. Petalite is effective in clear and opaque raw single fire glazed to cone 12.

When natural petalite is heated above 1,000°C there is an irreversible crystallographic inversion into a solid solution of silica in beta spodumene. This unique structure has virtually zero thermal expansion and provides the basis for low expansion ceramic bodies of unexcelled heat shock resistance.

Within the lithia-alumina-silica system there exists a broad compositional area of low-to-zero thermal expansion. Negative expansions are encountered in certain area. Such bodies can, of course be synthesized from pure chemicals and a wide variety of expansion characteristics can thus be obtained.

Because of these behaviors, petalite can be added to refractory mixes to improve their resistance to thermal shock. Such additions lower the P.C.E. of the refractory body but result in much longer life of refractories subjected to repeated severe temperature changes. Other lithium bearing ores such as amblygonite and spodumene can be used in the same manner.

Plaster of Paris

Calcined Gypsum, Calcium Sulfate.) $CaSO_4 : \frac{1}{2}H_2O$. A white, gray, or pinkish colored powder prepared by heating gypsum ($CaSO_4 : 2H_2O$) to remove three fourths of its water of crystallization. Available in various types of products having specific, controlled properties. When mixed with water and allowed to rehydrate to the dihydrate there is no apparent action at first, but soon a slight stiffening takes place and shortly after that it "sets" to a solid mass. As set progresses the mass begins to heat and expand, and final set is not reached until the evolution of heat has ceased and expansion is complete.

When suitably compounded with refractory substances, molds for the casting of non-ferrous alloy such as white metal, aluminum, brass are made with plaster. It is used in the manufacture of low density insulation and to provide green strength to mixtures of clay and non-clay refractories. In this use it can provide the set required to capture the frothy nature of lightweight refractories.

Much used by the manufacturers of finer ceramics for molds used in casting and jiggering processes, plaster of paris finds similar but less extensive use in the casting of complicated refractory shapes and for short run ramming molds.

Terra cotta shapes are formed in these ramming molds also and the same techniques can be used to make special brick shapes.

At elevated temperatures the sulphur is driven off and the material reacts as lime when used to bond bauxite, chrome or silica brick. In silica brick this is an important effect and the setting properties of the material enhance dry strength. The sulphur freed from the ware reacts with water to form sulphuric acid and is objectionable.

Potash

K_2O. Mol. wt. 94.2, sp. gr. 2.32, is very soluble in water and other solvents. The most important original source of commercial potash is natural potassium salts, which are mined in New Mexico, California, Germany, France and Russia. These are prepared as potassium nitrate and potassium carbonate for use in ceramics, but most of the potash is automatically introduced into batches in feldspar.

Its use, other than as a conditioner for clay, slips, engobes and as a glaze constituent, is in the elimination of green efflorescence on buff brick. If brick subject to green efflorescence caused by vanadium salts are treated with potash they will not develop the characteristic stains. A usual treating procedure involves dipping cubes of fired brick in a dilute solution of water and potash. When completely saturated, brick are removed and allowed to dry. The literature mentions a .4% solution although doubtless the proper amount will depend on total amount of soluble salts present in the brick and the absorption of the brick.

Potassium Carbonate

K_2CO_3. Commonly called pearl ash or potash. Mol. wt. 138. Although formerly imported, all domestic requirements at present are being supplied by American producers who distribute a product made from the electrolysis of potassium chloride from deposits located in California and New Mexico.

In this hydroxide or carbonate form, potash is an important deflocculating agent. It is used at ordinary temperatures to prepare casting slip, glaze slips, and engobes, to purify clay, to reduce the plasticity of excessively plastic clays, and to neutralize any acid present.

In glazes, potassium carbonate appears as an ingredient when it is desirable to modify the effect of a colorant such as copper oxide which may thus be brought through tints of green toward yellow. When potassium carbonate is used in colored glazes, it is advisable to frit about 90% of the clay but none of the color.

Rutile

TiO_2, Sp. Gr. 4.2-4.3 The mineral mined in several places in the United States and in several foreign countries is an important source for titanium oxide. However rutile contains 5% or sometimes less of various oxides of iron, chromium and vanadium. The material can be used to color clay products advantageously. Color developed depends on the mesh size of the rutile and the source, as varying amounts of impurities effect the results.

Granular rutile from Virginia will develop strong lavender colors and can be applied to stiff mud brick with sand blasting or as unground portions of engobe rolled, sprayed or poured on the column. Mesh sizes of 200 and 400 are available and will produce yellow and buff in small concentrations on the order of 10 to 15%, and larger additions to the sand will result in orange.

Used in the mold release sand for the production of soft mud brick, extraordinary colors will be produced. Lower temperature maturing ware might require some type of carrier to insure superior adherence of the rutile colorant to the face of the brick.

Pyrophyllite

$Al_2O_3 : 4SiO_2 : H_2O$. One of the rather large family of hydrous aluminum silicates. Often confused with talc, as the two minerals have almost identical physical properties. However, pyrophyllite is an aluminum silicate, whereas talc is a magnesium silicate. It is very soft, with hardness between 1 and 2 and specific gravity of 2.8 to 2.9. It is found in North Carolina, Pennsylvania, California and Newfoundland.

Used in varying proportions as a part of refractory units where the very low rates of thermal expansion and contraction tend to increase resistance to spalling and cracking. The major difficulty in its use is the lack of plasticity of the material and the resulting loss to be expected in the forming operations.

Used in minor proportions in otherwise difficult clays it will increase or decrease the maturity temperature, depending on the impurities in the clays and pyrophyllite, and reduce shrinkage in firing. In glazed ware it is reported to reduce or eliminate crazing.

Sawdust

Purchased as mill byproduct in most cases, the purchaser is not able to always secure the type and kind best suited for the purpose he intends to use it for. Generally sawdust from soft woods will be larger in particle size than hard wood dust and usually not as suitable. Average weight of sawdust is 20 lbs. per cubic foot and is usually sold in units of 200 cubic feet.

Average moisture content ranges around 40% and when used as a component of structural or refractory products the heating value of the sawdust will reduce the amount of primary fuel required. One pound of sawdust will produce approximately 5,000 B.T.U. When particle size is important fines can be removed with air separating equipment and over size pieces or dust reduced to any desired size with grinders, crushers or hammer mills.

Sawdust can be used in the soft mud, the stiff mud and the dry press methods of making brick. Added in the pug mill or a mixer varying percentages of sawdust can be added as a method of reducing the weight of the product, increasing the drying rate and effecting economies in firing.

Used as early as 1885 in the U.S., sawdust and clay bodies were widely used in fireproofing tile production and was known as "terra cotta lumber." In some plants using a slop on the faces of the brick for architectural effect, sawdust is used on top of the slop or mud to prevent brick from sticking when they are "faced." In this use sawdust can be spread mechanically.

Sawdust can be added to fireclays and the resulting mix made into any standard refractory size and fired. The density of the resulting refractory can be controlled by the proportion of the clay and dust but the compressive strength suffers as the unit is made lighter. Service temperatures are controlled by the fireclay used. Some sawdust is improved by roasting before use which can be done in rotary ovens but the charring should not be done above 600-650°. This tends to reduce the amounts of volatile material released from the mix during firing and eliminates all of the water vapor.

Used in structural clay products, the sawdust reduces weight, improves insulating properties and when used in large percentages produces a unit so porous that it can be nailed and cut with steel tools.

Primarily used in refractories to produce insulating units, lighter mixes produce good "U" factors but at considerable sacrifice in compressive strengths.

Silica

Silica occurs in a number of crystal forms, the nature and stability ranges of which have been extensively studied. This study has been difficult, partly due to the slow rate at which the changes occur, and the low thermal conductivity of silica and silicates, which tends to mask the results and prevent precise determinations. Sosman regards the allotropic changes as partly structural and partly atomic; he regards the sluggish changes as being due to the rearrangements of the silicon and oxygen atoms, and the rapidly reversible changes as being due to changes in the relative positions of the electron orbits which unite the atoms.

While tridymite and cristobalite may exist for indefinite periods of time at room temperatures, the low temperature or alpha form of quartz is the only form of silica truly stable at these temperatures. A considerable expansion accompanies the conversion of alpha cristobalite to beta cristobalite in the temperature range of 220-275°C and a sudden expansion of about 1% occurs during the inversion of alpha quartz to beta quartz at 573°C. The inversion of quartz to tridymite at 870°C is accomplished by an expansion of about 15%. These abrupt volume changes cause strains in a body containing free silica.

In recent studies at Alfred University and their ceramic college, it has been found that the crystal changes of silica are considerably responsible for the cracking of brick and tile in the heating up and cooling stages. Temperature curves can be so arranged that brick with high free silica content can be taken through the dangerous periods slowly and evenly to prevent any cracking or straining in the body.

The same phenomenon occurs in cooling. If a brick is cooled too rapidly and is subjected to these silica strains, it will be cracked throughout the cooling. Such a brick must have a longer cooling period to allow the complete transformation of the crystal to the more stable form.

BRICK AND CLAY RECORD in discussing firing curves, both in the Hanley story, 1955, and the Kelsey-Ferguson story, 1956, pointed out that brick can be cooled rapidly and heated rapidly in those stages where silica inversions do not occur and if organic substances are fired out. In both of these operations firing curves are very rapid, time is rapid and production is very high from tunnel kilns. The curves are based on proper knowledge of the silica inversion point.

All forms of silica, when heated to sufficiently high temperatures fuse and form amorphous silica glass or fused silica. If the heating is very rapid, quartz may fuse without appearing to pass through the intermediate stages. When fused silica is very slowly cooled, the reactions taking place are the reverse of those occurring during heating and alpha quartz will ultimately be produced

Very successful refractories have been made by adding fused silica to the body. Quartz in itself, after it is fused, has a very low coefficient of expansion and actually assists in bringing out a good heat resistant type of body. There is a danger of recrystallization of quartz if reheated too high and too many times, which of course would destroy the low coefficient of expansion.

Silica refractories are made from gannister and quartz rock. These refractories are very commonly used in roofs of glass tanks and open hearths.

The rock is brought into the plant and ground up to a definite range of mesh. The silica then is mixed with a binder, sometimes even molasses, and then shaped into form either by dry pressing or by drop press. Silica is fired to approximately 2700° for the final formation.

Lime is sometimes used as the binder and acts as a flux too.

Two types of silica refractories are made, one of the ordinary variety and the second with very low content of alumina as a contaminating mineral. Alumina up to possibly 4% acts as a flux, bringing down the service temperature of the pure silica brick.

In some heavy clay products plants where clays are gummy and very fine grained, silica is added to open up the clay body.

Silica is used in all glazes as the chief, and often the only, acid radical (RO_2 group). It may be adjusted to regulate the melting temperature of the glaze. In common glazes, the ratio of silica to bases (RO group) is never less than 1:1 nor more than 3:1. By varying the relative proportions of the RO group and balancing the group against any desired silica content, the maturing temperature of a glaze may be quite closely controled. In other words, the fusability of the glazes used in the presence of equal proportions of fluxes depends on their relative silica contents.

Silicones

A series of polysiloxane compounds, the structure of which has alternating silicone and oxygen atoms (Si-O-Si-). The structure is comparable to that of a carbon chain and, as in organic chemistry, the length of the chain and the degree of crosslinking determine the form of the silicone. Chains are longer and crosslinking is introduced and increased as the form moves from a fluid to a rubber to a resin.

The silicon atom has an atomic number of 14 and as such is normally tetravalent. The bonds which are not tied up in the polymeric network can be used to link organic components, the size and nature of which contribute greatly to the properties of the silicone.

The first step in the production of a silicone is the reduction of silica, SiO_2, elemental silicon by reduction with carbon in an electric furnace. The silicon is then reacted with organo chlorides to form organo-chlorosilane, which is hydrolyzed and polymerized to the desired material.

One of the outstanding properties exhibited by these unusual materials is a high water repellency which has been used for several years to waterproof existing walls and other porous structures. When walls are treated with silicones, they are still permeable to water vapor allowing any trapped water to move from the wall by evaporation and equalizing vapor pressures on both sides of the water repellent.

A technique of applying the silicones to individual brick has been developed which offers outstanding advantages to a large group of face brick manufacturers. By eliminating water migration through the brick, efflorescence from any source, (brick, mortar, water or nearby concrete), can be eliminated and the finished wall will further resist air and water borne soil much longer than an untreated wall. As water is the major disruptive force, walls kept dry in this manner will resist spalling, and crumbling due to freezing.

Two methods have been developed to apply the silicone, spraying and dipping. The concentration of active silicone in the carrier must be worked out for each application.

Sillimanite

$Al_2O_3 : SiO_2$. This mineral, having the same chemical composition as andalusite and kyanite, is often confused with them. There are important differences in properties. Sillimanite has a specific gravity of 3.23 as compared with 3.16 for andalusite and 3.60 for kyanite. Both andalusite and sillimanite crystallize in the orthohombic form, while kyanite has a triclinic structure. Sillimanite has a hardness of 6-7, andalusite has 7.5, while kyanite varies from 4 to 7.

Upon heating, sillimanite decomposes into mullite and silica, but not until the temperature reaches 1545°C. On further heating to 1810°C the material breaks up into corundum and glass.

Soda Ash

(Sodium Carbonate, Sal Soda.) This salt has the basic composition Na_2CO_3 with mol. wt. 106, specific gravity 2.53 and melting point 851°C. However, it may also appear as $Na_2CO_3 : H_2O$ (crystal carbonate) or $Na_2CO_3 : 10\ H_2O$ (sal soda). Soda ash has a theoretical solubility of 45.5 grams / 100 ml at 100°C but only 7.1 grams / 100 ml at 0°C.

Most soda ash is made by the Solvay process although a certain amount is prepared from lake brines and by electrolytic methods. "Commercial" grades of soda ash are available as 48% (Na_2O) light and dense and as 58% light and dense. Light and dense refer to apparent bulk density. Ordinary 48 to 58% grades are available in either light or dense but contain NaCl which may affect certain ceramic uses.

Soda ash is an active flux in ceramic glazes but can be used only as a frit ingredient because of its solubility. Na_2O added as soda ash in glaze frits supplements Na_2O from borax and feldspar components.

The deflocculating effect of soda ash in glaze frits supplements Na_2O from borax and feldspar components.

MODIFIERS Continued

The deflocculating effect of soda ash upon clay-water systems is an important phenomenon in several branches of ceramic body preparation.

In the presence of small quantities of soda ash the water of plasticity of bodies will be greatly reduced with consequent improvement in workability, greater green and dry strength and less cracking. This is particularly true where strongly flocculant ions such as Ca_{++} or SO_{4}— appear in the clay. High lime structural clay bodies are one example.

In this use they can be added in the pugging water or dry with accurate mechanical feeders to the clay any time prior to its delivery to the pugger. Fractions of 1% are usually all that is required.

In addition to the improvement of working properties of these types of raw materials the color of the fired ware is affected, usually to make stronger and more marketable shades.

Soda ash will react with massive lignite in certain ball clays to produce a very soluble and highly effective organic dispersing agent. Sodium silicate reacts much less strongly with massive organic inclusions so that under some circumstances soda ash is a far more effective deflocculant than sodium silicates. Normally, where lignite is low or absent, sodium silicate makes for lower viscosity than soda ash. Frequently, the two will be used in combination in a ratio suited to the type of deflocculation required.

Sodium Chloride

(Common Salt.) NaCl. Available in many qualities, bagged or in bulk. In most plant uses, lower qualities are quite satisfactory. Can be used as a bleaching agent in slips and glazes where it overcomes the effect of small quantities of iron oxide.

It is used in large quantities to glaze sewer pipe and, to a lesser degree, brick and tile. Not all clays are suitable for salt glazing. Barringer has reported that clay with a 3 to 8 silica to alumina ratio will salt glaze if sufficient temperature can be developed. The glaze itself seems to be 20% alumina, 54% silica with the balance being soda and other oxides.

In practice salt is applied as a vapor, created by throwing salt into the fire boxes of a periodic kiln after the kiln has reached a high heat. The salt vapor is carried into the ware area and condenses on all surfaces that it touches. In periodic practice, salting is repeated several times, the exact number of times is determined for each plant by experiment. As salting reduces the temperature quite rapidly the heat must be built up between saltings.

Salt vapor has a drastic effect on many refractory brick causing rapid failure mostly by dissolving the refractory. Insulating fire brick, by slowing condensation, delays this process. The amount of salt used varies widely with different clays, but generally 5-10 lbs. of salt per ton of ware seems to be sufficient.

Tunnel kilns can be salted, with salt vapors produced continuously in dutch ovens and pulled into the salting section of the kiln with a separate salt vapor exhaust system. Some plants inject salt into the salting section as a saturated water solution. In this installation, the volume change of the water vapor tends to build up a pulsating pressure in the section as the solution is added intermittently.

The salting temperatures of ware varies from cone 02 to cone 7 with the lower temperatures causing some difficulties. Salt glazing can be promoted by using a reducing atmosphere immediately preceding salting or by coating the ware with a "salt" coat which consists of finely ground clay applied to the face of the ware and which reacts more readily with the salt vapors.

Salt glazes are usually under tension which leads to crazing, lower pipe strengths and is not desirable. Additions of borax up to 10% reduce the tension and the defects resulting from it but does not eliminate them.

Under slips can be used in salt glazing and the color oxides can be mixed with the salt to develop glazes depend on the color of the body and firing conditions during firing, salting and cooling. They are colors not normally seen. The natural colors of salt range from clear to black.

Sodium Pyrophosphate, Tetra

$Na_4P_2O_7$. A prepared chemical, containing no water of crystallization, available in granular and finely powdered forms. It dissolves in hot or cold water and is mildly alkaline in solution. It has a pH of 9.1 to 10.3. It is an efficient suspending and dispersing agent for grease, dirt, clay and other insoluble materials, which leads to its use in the ceramic industry. In clay slips the material is used as a dispersing and thinning agent. Approximately 1¾ lbs. are used to disperse a ton of clay.

It is used as a deflocculant in glazes and in the purification of clays. It is also used as a means of removing iron from clays by washing. It is an efficient water conditioning agent and as such may be used when the effect of hard water produces undesirable results.

Sodium Silicate

(Na_2O : x SiO_2.) A consideration of silicate of soda in the ceramic industry must be predicated on an understanding of what is meant by the term silicate of soda. In a commercial sense, silicate of soda is no more definite a term than clay. Its connotation is generic rather than specific. Attention must be called to this fact because in spite of voluminous literature there are still many technical men who think of a definite sodium silicate when they see the syrupy liquid of commerce.

Sodium silicate is made by melting sand and soda ash in a reverberatory furnace. Various proportions of the two ingredients are used and widely divergent characteristics result. The most alkaline liquid silicate made by this furnace process has a ratio of 1Na_2O to 1.6 SiO_2 and the most siliceous liquid grade has a ratio of 1 Na_2O to 3.75 SiO_2. There are more alkaline sodium silicates made which are detergents and are known as metasilicate, sesquisilicate and orthosilicate.

The melted sand and soda ash coming from the furnace may be put immediately into solution. The most silaceous grade cannot be concentrated beyond about 32% total solids without going to a gel, but the most alkaline liquid can be concentrated to about 61% solids and still remain fluid. Instead of forming solutions, the melt may be a cooled to a glass which can only be dissolved in high pressure steam.

Because of the many grades of silicate and the great differences in their characteristics, it is evident that the proper selection is of importance to obtaining good results, and the manufacturers are usually well equipped to give technical advice which will enable the user to obtain best results with a minimum of energy.

Sometimes for reasons of economy and many times for reasons of better workability or improved finished product, sodium silicates are used as additives in various clay products and refractories. The sodium silicates, liquid and powder, are beneficial in varied applications such as in casting slips, clay mining, refining and treating, bricks, enamelware and glazes, Faience tile, roofing granules and refractory cements.

In processing raw clays the deflocculating action of sodium silicate is used to separate impurities such as quartz, feldspar, mica, and iron oxide. One to four pounds of silicate per ton disperses the clay and permits the heavy impurities to settle out. The ore suspensions of deflocculated clay can be pumped to settling basins more economically than by other means of transportation.

Powdered metasilicate is added to the finished clay as a dispersant for the convenience of users.

Sodium silicate acts as a dispersing agent in clay suspensions to produce high fluidity and minimum water content. 0.1% of sodium silicate converts a stiff clay mud into a thin liquid which can be poured or pumped without difficulty. The reduction in water content of a cast slip results in a shorter firing time, less shrinkage or warpage of the finished ware, and greater strength.

Light weight insulating bricks are made from vermiculite or perlite by bonding with sodium silicate and calcium carbonate or similar reactants.

Silicates serve as a source of silica in porcelain and metal formulation. Since the silica has been fused with alkali, its use permits a reduction in the temperature required for fritting.

Silicates are used in Faience glazes to give artistic effects such as "crackle" or a fine crack design.

Silicates provide bonding strength at room temperatures. Powdered silicates are used in the dry clay type bonding mortars to be mixed with water just before use. Liquids are used with plastic chrome ore and other agents to formulate various types of furnace cements. Dry hydrated silicates are used with chrome ore formulations for gunning mixes to be used in patching while furnaces are under heat. Silicates provide temporary tack until the fusion effect of the other ingredients comes into play. They give greater green strength and greater fired strength in air set refractory specialties.

Sodium silicates are available in ranges from Na_2O : 3.75SiO_2 to 2Na_2O : SiO_2. Liquids range from 35.0° Baume to 67.5° Baume.

Starch

A group of carbohydrates or poly saccharides occurring in many plant cells. It is available in the form of a white soft amorphous powder. It is derived from several vegetable sources, corn being one of the more important. It finds use in structural and refractory products as a binder. (See Binders.)

Steatite

An hydrous magnesium silicate, being a massive variety of talc. Specific gravity and hardness are the same as for foliated talc. Steatite contains only about 3.75 to 4.75% combined water, so that firing shrinkage of the mineral is only about 4%. Therefore articles can be machined of crude steatite nuggets which are much more exact in dimensions than those made of porcelain mixes which have a greater firing shrinkage. The natural mineral may be machined to close tolerances to make ware from mined blocks, or it may be crushed into a powder and dry-pressed using a small amount of binder.

Sulfur

S. An element with atomic weight of 2.06, insoluble in water but soluble in a number of organic reagents. It is mined as native sulfur in Texas and Louisiana and Mexico as well as the volcanic regions of Italy, Japan and Chile.

Its compounds are sources of many difficulties to the structural and refractory manufacturer. Major trouble makers are iron sulfate or pyrites, magnesium sulfate and calcium sulfate. Materials containing these compounds evolve sulfur dioxide during firing and the gas combines with water to form sulfuric acid which destroys equipment and building. The balance of the compounds tend to mar the appearance and usefulness of the product in which they occur.

Tar

(Asphalt, pitch.) A complicated and variable material derived from petroleum as an end product of the distillation process. Tar has several uses in the refractory, brick and sewer pipe industries.

Its major refractory use is as a bonding agent in the production of carbon brick. In this use, the refractory mix must be heated to a point where the tar can be uniformly mixed and then the brick can be pressed in the usual manner. Patents and published material also illustrate some uses as a bonding agent for basic brick and in some cases silica brick. Carbon brick are often laid with a mastic type mortar containing tar. Tar is used as a convenient source of carbon in the "flashing" of periodic kilns.

When thrown into the fire boxes, dense clouds of black smoke are formed and it is likely that colloidal carbon particles are actually taken up into the surface of the brick.

In any event, the colors developed in this type of reducing atmosphere are different than when "flashing" is done without the use of tar. Salt added with the tar also affects the results, sometimes adding luster to the brick.

In the sewer pipe industry, tar is used as a joint material. Rings of tar on the bell and spigot ends are formed in the plant with metal molds. When used, the tar ring is washed with a solvent and the ends pushed together. The joint formed is not elastic but in non-severe use has proven to be satisfactory.

Terra Sigillata

A coating material prepared by decanting ground clay to retain only the smallest clay fractions. Clays so altered can be sprayed, rolled or dipped onto bodies of the same clay or from clay of different origin. On firing, the ultra fine terra sigillata forms a glassy phase at lower temperatures than the same clay of more usual particle size. Clay can be chosen for particular colors or for light firing material can be tinted with common colorants. When using terra sigillata on bodies prepared from the same clay, physical fit is assured and adherence is good.

Clay containing illite and kaolinite are best suited to produce terra sigillata material. The montmorillonites are not suitable.

Umber

An iron oxide coloring material containing significant portions of manganese. It is temperature sensitive and develops browns and blacks. (See Ochre.)

Vanadium Oxide

In special refractories, vanadium tetra oxide forms a number of refractory combinations with fusion temperature above 1540°C. V_3O_4. Tends to be unstable in air and V_2O_5 the resulting form has a marked reduction in refractoriness.

Vanadium can be used in glazes as a tinting color.

Salts of the metal have been blamed for the green efflorescence that sometimes appears on light colored brick. Control is difficult though some producers find dosing raw clay with fluorspar reduces or eliminates the problem. Others find treatment of fired brick with potash solutions inhibited the appearance of the green stains. Recent developments of plant applied silicone formulations to fired brick appear to be one economical way to control the migration of the salts.

Vermiculite

$(OH)_2$ $(MgFe)_3$ $(SiAlFe)_4$ $O_{10}4H_2O$. A peculiar type of mica that when heat treated expands 16 to 20 times its original size. The expansion is in one dimension much like an accordion. It is inert and is fairly refractory. Used as a grog in clays it reduces tendencies toward lamination and, being slick, acts as a lubricant for auger and dies.

Being resistant to fairly high temperatures it can be used as a grog for light weight refractory brick or as an aggregate for cast refractories.

The material occurs in South Carolina and Montana. It is shipped unexpanded after mining and sizing with the expanding being done near centers of use.

Volcanic Ash

(Volcanic dust, pumicite.) Volcanic glass blown into the air during the eruption of explosive types of volcanoes and deposited hundreds of miles from the source. The chemical composition of volcanic ash is similar to that of granite or rhyolite, but the rapid cooling of the material prevented the formation of minerals. This material occurs as a loosely consolidated gritty powder ranging in color from white to light gray. Deposits vary greatly in thickness and extent. The larger deposits contain reserves in excess of 100,000 tons and range in thickness up to 30 feet. Volcanic ash occurs in commercial quantities in Kansas, Nebraska, Oklahoma, Texas, Colorado, Idaho, Montana, Oregon, California and in British Columbia and Saskatchewan in Canada.

Volcanic ash is a naturally pulverulent material. Screen analyses of 70 samples from widely distributed areas in Kansas indicate that only 1 to 5% is retained on a 100 mesh screen and from 75 to 90% passes a 200 mesh screen. The pyrometric cone equivalent of Kansas, Oklahoma and Nebraska ash ranges from Cone 04 to 4, and this probably applies to volcanic ash in general, although one sample from Montana had a P.C.E. of Cone 8.

Its use in glazes is limited by the color change caused by the iron content but it finds use as an addition to clay bodies.

The use of volcanic ash in some types of sewer pipe bodies is advantageous because the low cost material permits vitrification over a wider range and imparts toughness to the finished product. The optimum percentage that should be used in a ceramic body of any type seems to be in excess of 7% but not more than 25%.

It lowers the maturing temperature of brick in the same manner and has been investigated as a ceramic bond in the production of lightweight aggregate clay block. Being extremely plentiful, the cost is attractive in areas where deposits are located.

Work indicates that the material can be expanded. A unique method reported indicates that the material can be mixed with the air of combustion and carried by that medium into the flame through an aspirating natural gas burner.

Whiting

Calcium carbonate prepared from certain sources. Originally from chalk cliffs in England, France and Belgium and then domestically from marbles or calcites. The term is being widened in use to include any fine calcium carbonate.

Witherite. Native barium carbonate.

(See Barium Carbonate)

Zinc Oxide

The use of zinc oxide in the heavy clay industry is in glazes. In glazes for brick, sewer pipe, tile, etc., zinc oxide serves in several different capacities, all of which are beneficial in developing high-quality products. Dependent upon the glaze formulation, the firing procedure, and the characteristics of the body, zinc oxide plays an important role in developing different properties in a fired glaze.

Zinc oxide is used to reduce the coefficient of expansion of the glaze, thereby helping to make the glaze "fit" the body. Crazing of the glaze may thus be eliminated. It improves the elasticity of the glaze, thereby improving its resistance to mechanical and thermal shock. Because of its fluxing action and broadening of the maturing range, zinc oxide in glazes in proper amounts improves the gloss.

However, in larger amounts, in a properly formulated glaze, zinc oxide is used to develop various textured glazes such as matte, eggshell, or crystalline. Certain colors are developed or enhanced by zinc oxide, and it also functions as a secondary opacifier.

The last property to be mentioned is that zinc oxide helps to make a glaze highly insoluble. This is particularly important for heavy clay products. Insolubility of a glaze coupled with crazing control are to be considered as extremely important properties in a glaze applied to heavy clay products, whether they are used inside, outside, or underground.

Wollastonite

$CaSiO_3$, Sp. Gr. 2.9, 4.5 hardness on the Moh's scale and P.C.E. of cone 18. This is a naturally occurring silicate which has been used in comparatively large quantities in ceramic tile bodies, glazes and electrical ceramics. Recently it has been reported that the addition of as little as 1-3% to typical structural clay bodies results in improvements of forming, drying, firing and quality of finished ware.

The Wollastonite particle is needle-like and it is thought that a jackstraw effect tends to open the clay body to allow the escape of water vapor during drying and the early part of the firing cycle. During the later stages of firing the same effect is observed on the products of ignition.

The material can be added with an accurate dry feeder to the pug mill.

According to a paper written by Jackson and Vukovich, additions of 1-3% Wollastonite increased dry strength of structural clays up to 40% and in laboratory firing of test bars allowed the firing rate between 900-1100° F. to be more than doubled.

A reduction in moisture expansion of autoclaved test bars containing Wollastonite was noted and this reduction ranged from 30% of the untreated value for minimum addition to 66% for additions of 3% to one of the clays tested. This effect would be expected to reduce delayed crazing of glazed structural tile after long periods of service.

Zinc

Zinc metal is used for flashing colors directly onto the body of the clay ware. The only use it is put to in the heavy clay industry is in the development of "flashed" colors on building brick. A mottled arrangement of colors ranging from dark brown to a dull green to a sort-of-yellow can be developed by exposing the brick, during the firing cycle, to the action of zinc vapor. This can be affected by adding mossy zinc to the fire box where it is vaporized.

Zirconium Oxide

Mol. wt. 123 and sp. gr. 5.7. It melts at 2700°C and has a low thermal conductivity.

To prepare useful products from zirconium oxide, stabilizing agents such as lime or magnesia must be added to the zirconia, preferably during fusion, to convert the zirconia to the cubic form. Most commercial stabilized zirconia powders or products contain calcium oxide as the stabilizing agent. The "stabilized" cubic form of zirconia undergoes no inversion during heating and cooling.

Stabilized zirconia refractories are used where extremely high temperatures are required. The low thermal conductivity insures low heat losses, and the high melting point permits stabilized zirconia refractories to be used continuously or intermittently at temperatures above 4000°F in neutral or oxidizing atmospheres. Above 3000°F in contact with carbon, zirconia is converted to zirconium carbide.

- Vitrifies at low temperatures.
- Stops formation of green scum.
- Costs approximately 50c per ton of clay.

Just 50c worth of Minerva Fluorite in every ton of clay insures precise color control of all light face brick.

This powerful flux eliminates the need for hard firing . . . prevents formation of green scum by permanently locking vanadium and iron salts inside the brick.

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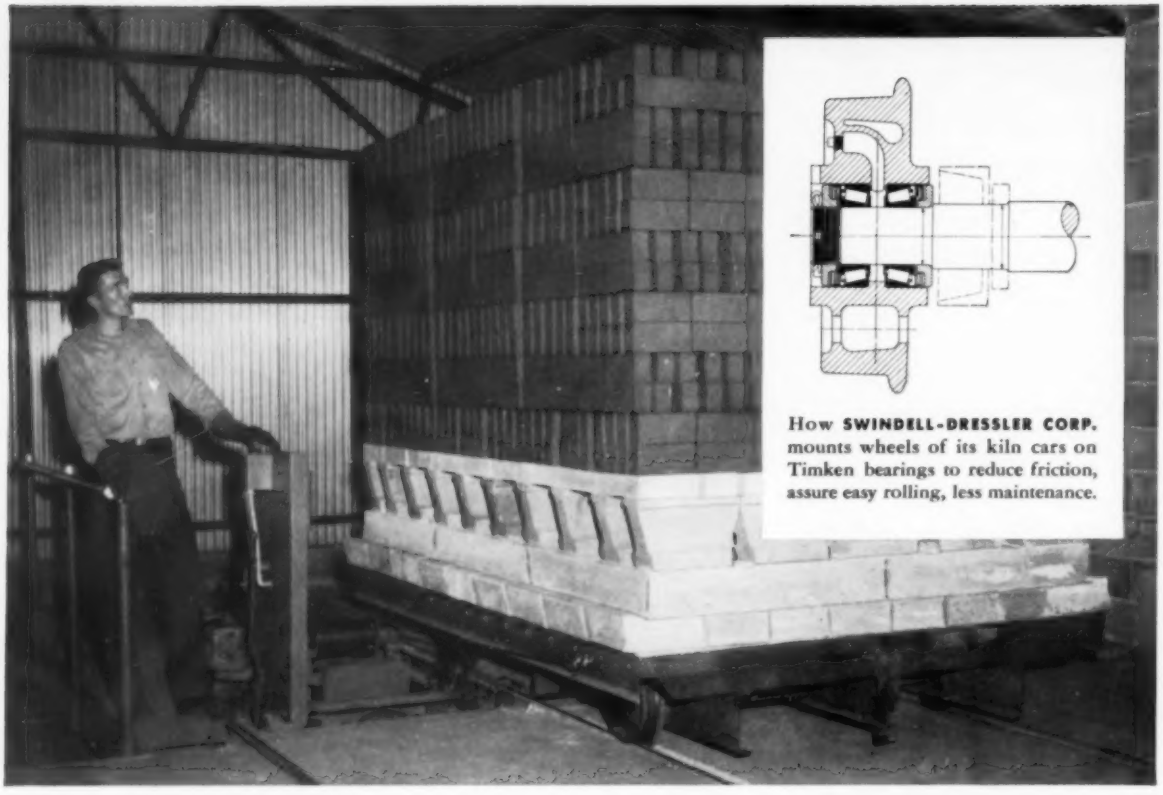

How **SWINDELL-DRESSLER CORP.** mounts wheels of its kiln cars on Timken bearings to reduce friction, assure easy rolling, less maintenance.

Now, one man can roll a kiln car with wheels on Timken® bearings!

WHAT used to be a tough job for eight men is *now easy* for one—moving a fully loaded, 30,000 lb. kiln car. And doing it without pinch bars. That's because the car wheels, on the Swindell-Dressler Corp. car above, are mounted on Timken® tapered roller bearings. Swindell-Dressler's new kiln design provides precise heat control, keeping temperatures at the wheels below the critical range for efficient bearing operation. What's more, wheel lubrication is cut from once every pass through the kiln to only once every few months. It's no wonder Swindell-Dressler switched to Timken bearings on kiln car wheels. And easy to see why one kiln operator says, "they're the biggest advance in kiln cars in 15 years".

It's because Timken bearings . . . *1) Roll practically friction-free.* They're geometrically designed and precision-manufactured to roll true. They reduce starting friction, roll smoothly. They maintain their precision longer.
2) *Save lubricant and maintenance time,* because they make closures more effective in keeping lubricant in, dirt and dust out. Your maintenance costs *stay* down.

You can be sure of getting more for your money when you build or buy machines equipped with Timken tapered roller bearings. One reason is: Timken Company leadership in tapered roller bearing design. Another is the service you get from graduate Timken Company *engineer* salesmen—service you can't get anywhere else.

To be sure of better performance in the machines you build or buy, be sure they're equipped with Timken tapered roller bearings. ***When you buy Timken bearings you get . . .*** *1) Quality you can take for granted. 2) Service you can't get anywhere else. 3) The best-known name in bearings. 4) The pace setter in lower bearing costs.* The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*

First in bearings for 60 years

BETTER-NESS rolls on

TIMKEN®

tapered roller bearings

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They make many grades of brick by several methods.

But they *dry press* their premium quality face brick on two new Boyd Presses.

Brampton put Boyd Press in their blueprints for expansion to serve a growing list of customers, over a wide market area, who wanted a dense, smooth surfaced, square-edged face brick with exceptional dimensional stability.

You have customers and prospects in your area that are willing to pay top dollar for such a product.

It won't cost a red cent to investigate how Boyd *power pressed brick* may open up new avenues of profit for you. Write for details.

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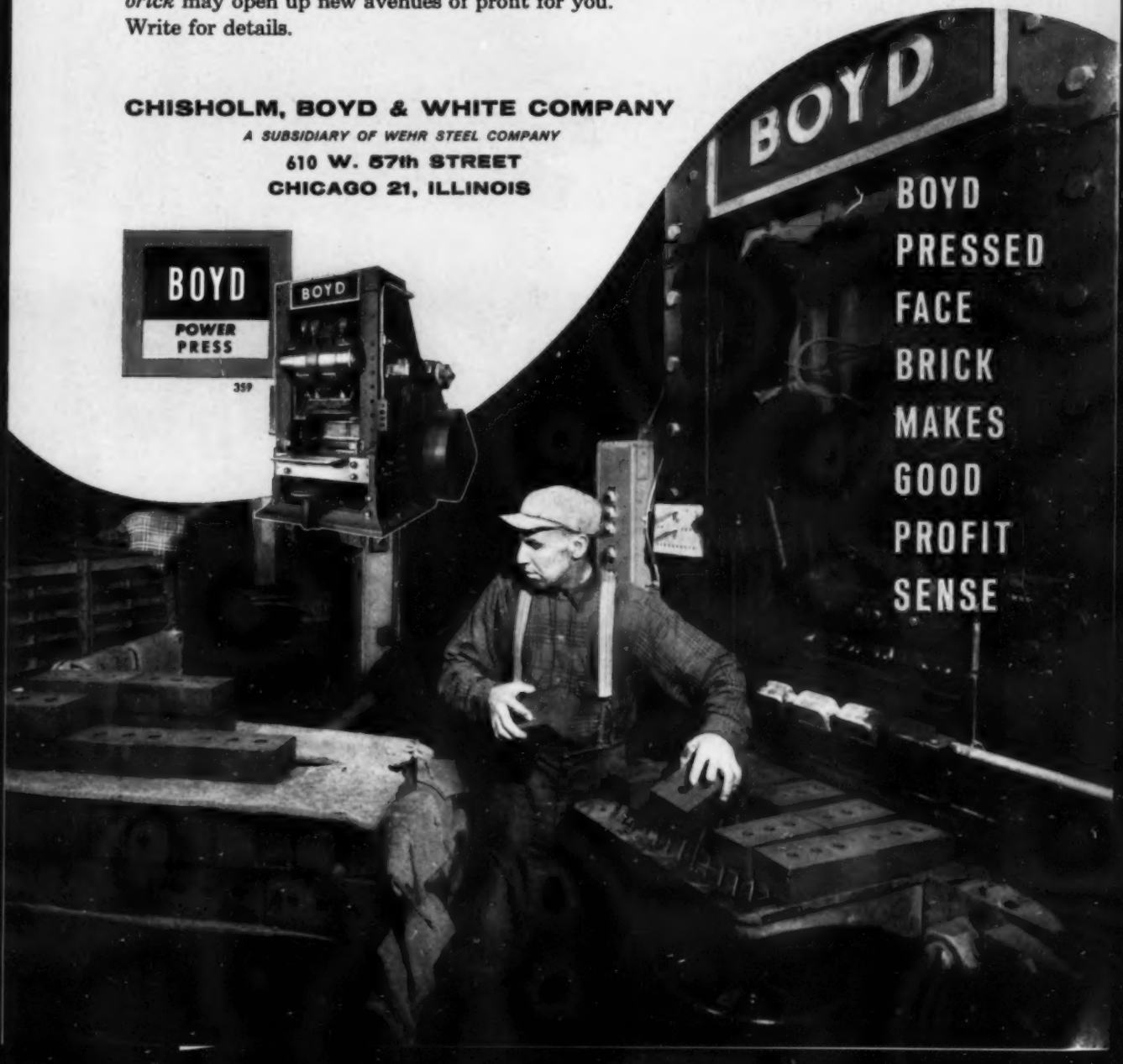

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This is the time to expand . . . and this is the way to do it—with Varco "Rigid Frame" Steel Buildings. A Varco building is engineered to last and to take it. Since time means money in the construction of a building, Varco will save you time . . . and money . . . by affording fast service on every contract. Skilled crews will have the prefabricated frames erected and under roof in only a few days. You always

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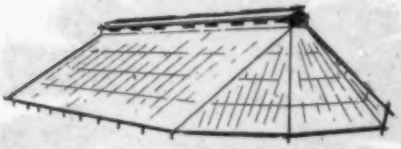
Strong, sturdy Varco Rigid Frames are designed to give your facilities and equipment the best protection at the lowest possible price. Your building will last longer, require less maintenance.



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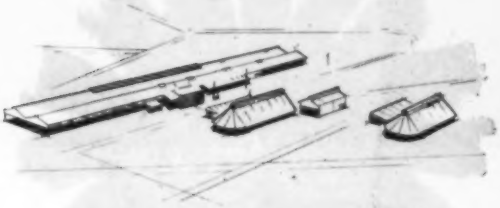
Clay Storage Buildings are a Varco specialty. Utilizing tubular framing with galvanized or aluminum covering, experienced Varco crews can give you economical clay storage. Size can range from five to 30-ton capacity, or even larger if you desire.



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If you're thinking of a new plant, take advantage of Varco experience in planning the buildings that will give you highest efficiency . . . lowest production cost. Varco will work in close coordination with you or your engineering firm.

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get better service from a specialist, and Varco is a specialist in buildings for the brick and clay field. *More Varco Buildings are being erected than any other type structure in the brick and clay industry.* There's a simple reason why: Varco builds it better . . . for less. Find out for yourself. Ask a Varco customer. Then, write for more information about the building you need to stay on top in this booming industry.

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Three special grades of "PYRAX" pyrophyllite have been developed for use in refractories.

Refractory grades of "PYRAX" pyrophyllite can be used to good advantage in refractory brick, refractory cements, unfired refractories, backwalls, radiants, tile setters, saggers, and other special refractories.

"PYRAX" pyrophyllite has a P.C.E. of cone 26 to 27 and when mixed with small amounts of kyanite its P.C.E. can be increased to cone 28 or 29.

"PYRAX" pyrophyllite refractories when properly compounded have a high strength, will not spall or fail due to temperature gradient.

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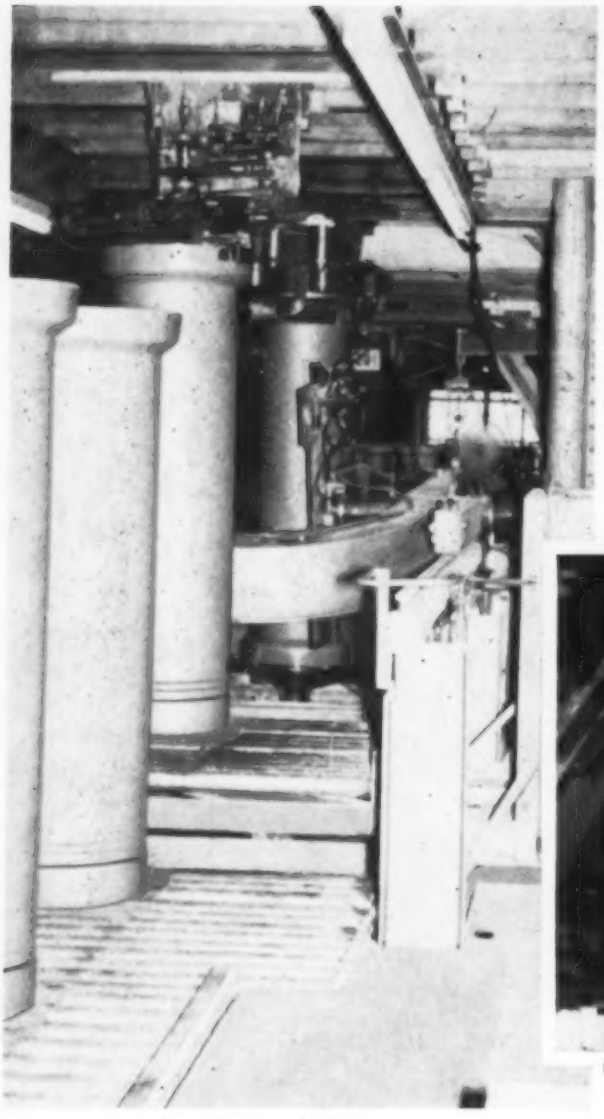
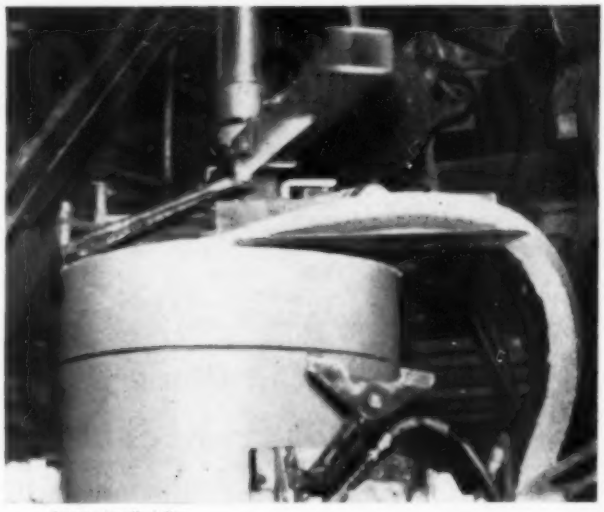


Note low head room

The "OCTOPUS"

Complete Automatic Production of Pipe with Drying Rings



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1—Removes large pipe from vertical press (No socket boards required)

2—Finishes both spigot and socket ends

3—Cuts pipe to length

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5—Automatically places pallet board

6—Turns and places pipe on drying ring and pallet board

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Number of men needed for above operations ..... NONE

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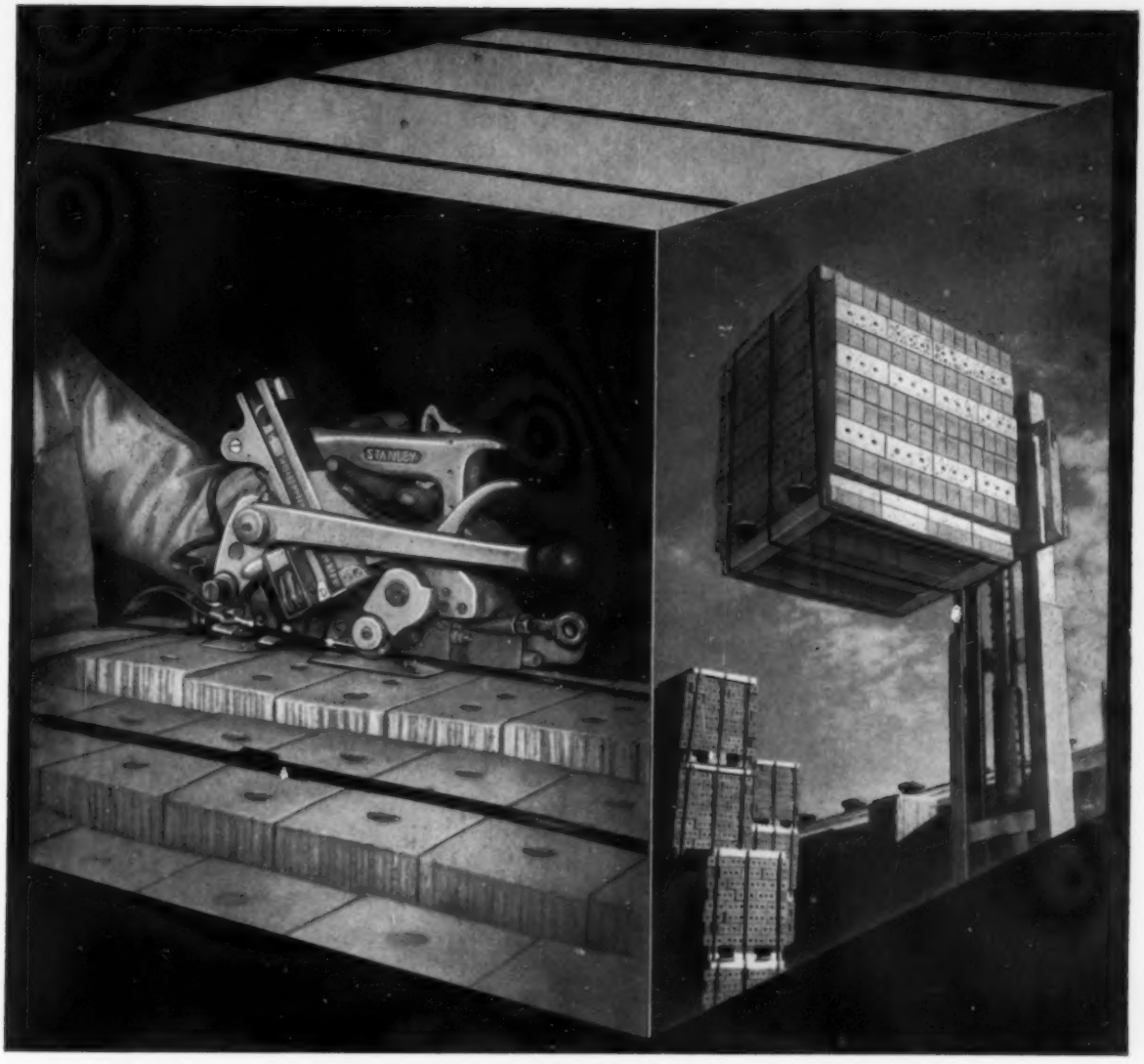

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When The Huntsville Brick and Tile Co., of Alabama, handled brick manually, it required 90 minutes to load each truck with 6,000 brick. 5% of the company's entire output was lost through brick breakage!

The Stanley Steel Strapping Specialist came along with a new packaging idea and the Stanley Electric Skid Magazine Tool. Now, bricks are Stanley steel strapped into 500-brick packages, with Stanley ESM Tool. Loading time has been reduced 83% and brick breakage cut from 5% to less than 1%!

Perhaps you need a new packaging idea, or a more efficient steel strapping tool. Write for Data Sheets to STANLEY STEEL STRAPPING, Division of The Stanley Works, Dept. H, 1308 Corbin Ave., New Britain, Conn.

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This famous trademark distinguishes over 20,000 quality products of The Stanley Works, New Britain, Conn.—hand tools • electric tools • builders hardware • industrial hardware • drapery hardware • automatic door controls • aluminum windows • stampings • springs • coatings • strip steel • steel strapping—made in 24 plants in the United States, Canada, England and Germany.

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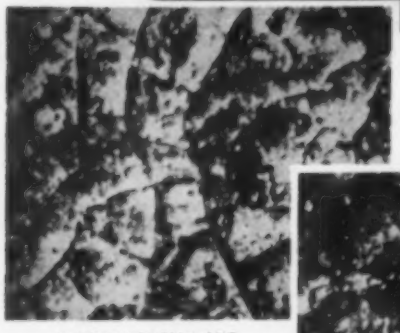
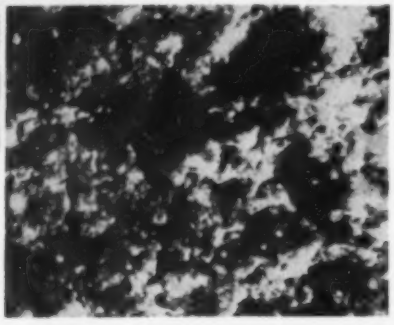
Compare these glazes



Here's proof of what a borate-salt mixture can do for your ware!

GLAZED WITH 100% SALT
BADLY CRAZED



GLAZED WITH 10% BORATE–90% SALT

for a better glaze at less cost...

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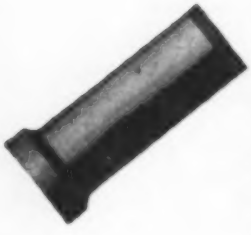

Improve your salt glaze, lower your costs—it's easy with RASORITE! This product is cheaper than either Borax or Boric Acid, yet it gives equally fine results. Use RASORITE to make your glazes more durable, more impervious to liquids, more uniformly free of crazing. Get the benefits of a borate-salt mixture—in lowered fuel costs, increased production and profits. Write today for details and technical data sheets.

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New Products Con't.

Stronger Firebrick

A stronger and improved insulating firebrick that is light in weight and low in thermal conductivity has been introduced. Known as B&W K-20 and K-23, the firebrick was engineered to meet the requirements of kiln builders and operators in the structural clay and allied industries. Increased mechanical strength of the units permits their use in a wider range of applications. The firebrick can be tailor-cut, drilled or shaped as necessary, eliminating the costly special shapes and delays involved in obtaining them.

Babcock & Wilcox.

10/Circle on Reader's Service Coupon

Pump-Tank Combination

A new, compact and low cost pump-tank combination with Proportioneers Model 1106 Adjust-O-Feeder for accurate general chemical feeding and for boiler water treatment, has been announced. The unit is designed to use a minimum of space. The tank, fittings and tubing are made of all corrosion-resistant materials suitable for handling most industrial chemicals. All the features of the Model 1106 Adjusto-O-Feeder are also present.

B-I-F Industries, Inc.

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Lift Arm Attachment

A new attachment—a combination lift arm and hook, lift arm and pallet fork and vertical clamp arms—has been added to the line of front end units now available for the Hi-Lifter fork truck. The new combination attachment is hydraulically controlled. The lift arm and hook is designed to lift a 2,000-lb. load at its 10-ft. forward reach and lift it 35 feet above the ground under the hook. With the lift arm and pallet fork, it is possible to lift a 2,000-lb. load on a pallet to 35 feet.

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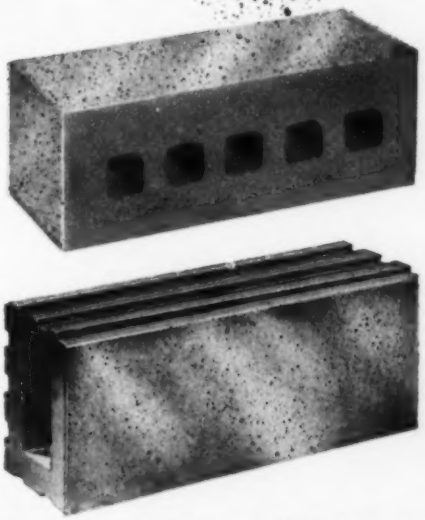
NOW... COLORED SPECKS

to brighten your profit outlook

Add colored specks to your glaze and your brick and structural facing tile will have that "wanted look" architects write into specifications.

Everyone likes specks. Drakenfeld has them in permanently bright colors – greens, pinks, blacks, yellows, blues, browns – in a variety of screened sizes. Single colors will turn out as peppered effects. You can use several colors to produce spattered surfaces. You can use specks of one color in a glaze stained a contrasting or complementary color. Or, it's easy to create attractive scatter patterns with a mix of colors. The possibilities are practically endless.

Architects want color and more color. Drakenfeld Colored Specks now give you another means of capitalizing on this trend. Write for samples, prices and application information.



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New Literature

Refractories—Two technical bulletins, one on chrome mortar, the other on chrome castable, have been published by the Refractories Division, H. K. Porter Co. Both publications are designed to serve as guides to basic product selection, use, application and service.

Refractories Div., H. K. Porter Co.

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Mulling—"A Handbook on Mulling" explains the mulling principle of blending dry, semiliquid and dry solid materials in the Simpson Mix-Muller. Charts and photos illustrate the action and principle of the machines.

Simpson Mix-Muller Div., National Engineering Co.

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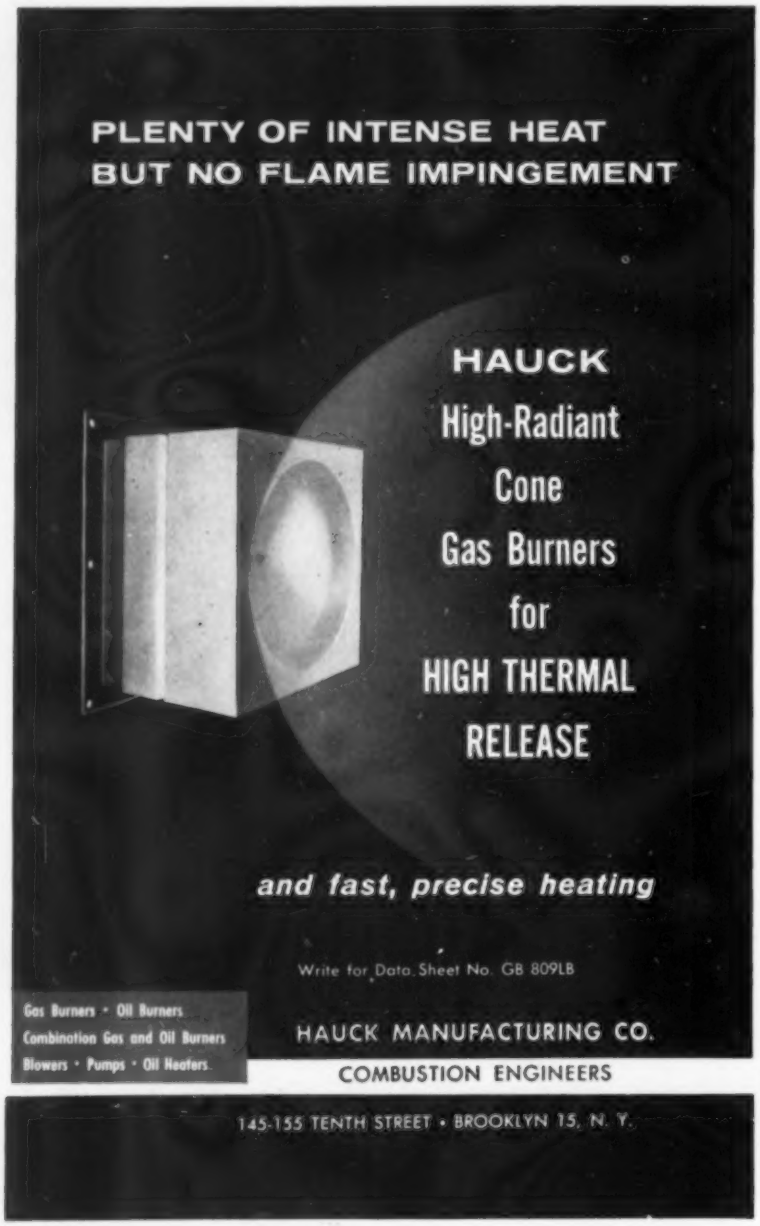

Industrial Gloves—New 16-page catalog illustrates complete line of Wil-Gard industrial gloves and finger cots. A number of sizes, finishes and materials are available.

Wilson Rubber Co.

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Color Data—A technical file of color data sheets is designed to aid in the production of colored glazes for various ceramic products. Each sheet gives recommended glaze formulas, grouped by pyrometric cone number.

Pemco Corp.

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Strain Gauge—A new 8-page bulletin, No. 2294, describes the Aminco-Tuckerman optical strain gauge, an instrument designed to measure strains due to tension and compression as small as 0.000002 in./in. Operating procedures, applications and other data are included.

American Instrument Co., Inc.

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Steel Strapping—New booklet tells how to save time and effort and do a better, more uniform job of steel strapping. It also gives useful data and descriptions of Signode's line of air power tensions and sealers.

Signode Steel Strapping Co.

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Thermocouples—Newly revised, fully illustrated Catalog EN-52 offers information about Leeds & Northrup's line of thermocouples and thermocouple components and accessories. Recommendations are given on choice and use of units.

Leeds & Northrup Co.

19/Circle on Reader's Service Coupon

Abrasive Wheels—Over 1600 experience-tested abrasive wheel recommendations for a wide variety of grinding applications are listed in alphabetical order in this new, 57-page specifications catalog.

Carborundum Co.

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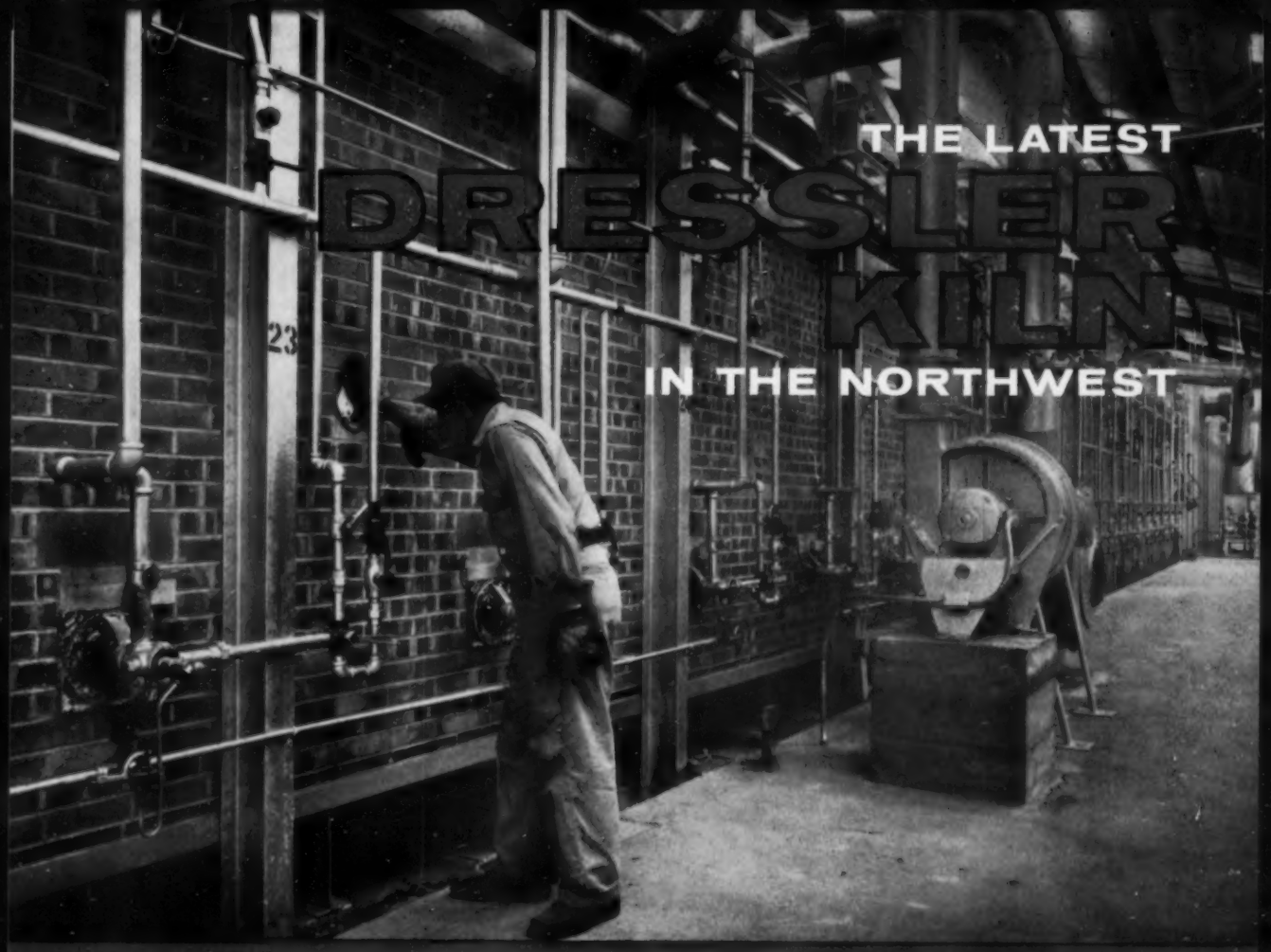
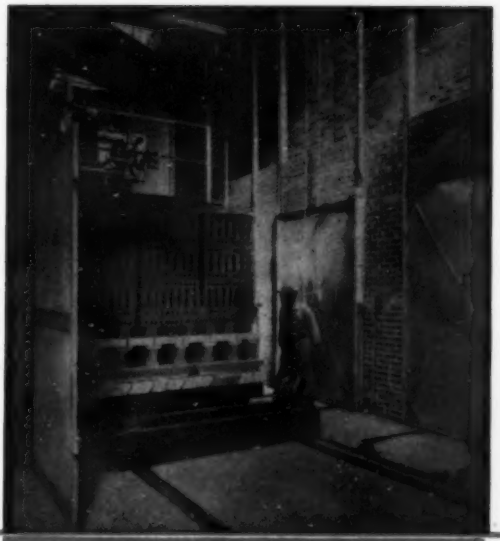


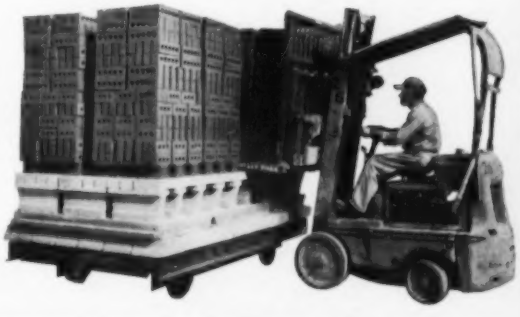
THE LATEST DRESSLER KILN IN THE NORTHWEST

...for Builders Brick Company Seattle, Washington



This high-production Dressler Kiln is 397′ long, and operates in conjunction with a 3-track dryer to fire all types of brick and tile. Annual capacity is 35,000 tons.

Let us consult with you on your firing problem and kiln requirements. Write without obligation of any kind.



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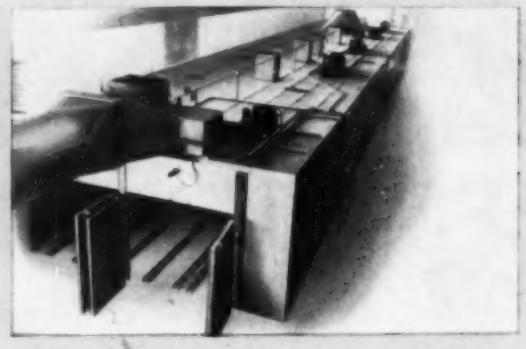

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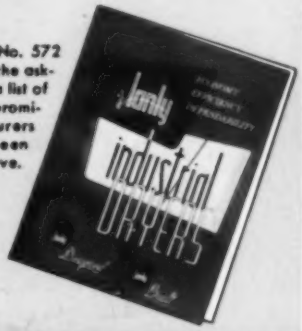

Atlanta, Georgia • Birmingham, Ala. • Boston, Mass. • Chicago, Ill. • Cleveland, Ohio
Toronto, Ontario • Columbus, Ohio • Detroit, Mich. • Buffalo, N. Y.
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Brick & Clay Record Joins With Boston Publishing Firm

Industrial Publications, Inc., combines with Cahners Publications to form one of largest trade publishing firms in U. S.

Norman L. Cahners

Maurice P. Driscoll

IN KEEPING with the modern trend toward expansion and diversification in business, Industrial Publications, Inc., publishers of BRICK & CLAY RECORD and five other leading business magazines, have joined forces with Cahners Publications of Boston. The combined enterprise is believed to be the fifth largest in the U. S. among industrial and trade publishing companies.

The enlarged operation will be headed by Norman L. Cahners as chairman of the board. Maurice P. Driscoll will continue as president of IPI and Fred L. Steinhoff will continue as publisher of B&CR. The present officers and staffs of each magazine will remain in their same capacities with the new set-up.

Editorial services to brick, tile, refractories, clay sewer pipe and lightweight aggregate manufacturers so ably performed for the past 17 years by executive editor, J. J. Svec, aided in recent years by Elmer Spain, technical editor and Alan Rose associate editor, will remain under their direction. Advertising sales activities of B&CR will continue to be headed by Floyd Burdick, who reports to John H. Van Deventer vice-president and general sales manager of all IPI publications and a 23-year veteran with Industrial Publications. Publication headquarters for B&CR will remain in Chicago.

In commenting about the transaction Mr. Cahners, the new Chairman said, "This is in keeping with the modern trend toward bigness in business . . . effects economies, provides diversification, adds depth to management." He stated further, "The sky rocketing growth of American industry has increased the responsibility of the business paper publisher. More and better information of all kinds is required. The need for greater services to reader and advertisers is constantly evident. These needs are better met as the publishing entity becomes larger and stronger."

Pooling Advantages

Mr. Driscoll pointed out that "subscribers to business and trade publications today are accomplished, highly successful business men whose interests must not only be expertly, but adequately handled by the magazines to which they look for help and guidance in solving their problems. These ends are more efficiently attained in the pooling of the two companies' ample resources, publishing talents and management experience."

Other Publications

Besides B&CR, Industrial Publications, Inc. publishes Practical Builder; Building Supply News; Building Construction Illustrated; Ceramic Industry; Ceramic Data Book.

Cahners Publications includes: Modern Material Handling; MMH Materials Handling Manual; Metalworking; Modern Plant Operation & Maintenance; Modern Assembly Practice; Supermarket Equipment.

Fifty Fabulous Years . . .

Cannelton Begins Second Half Century

Cannelton Sewer Pipe Co., Cannelton, Ind. marks 50 years of business operations this year with special celebrations and promotions. In the United States 50 years represents a milestone in the operation of any business. It is this milestone to which the following pages are devoted in an attempt to trace the growth and development of a pioneer clay pipe company into a modern and growing enterprise. The history of its development to the present should bring out those principles of management and those policies which have meant success.

With management now in the second generation of the same family and the third generation assuming even more responsible jobs, Cannelton Sewer Pipe founded in 1909 and since constantly expanding, serves as a case study of administration, selling and product promotion.

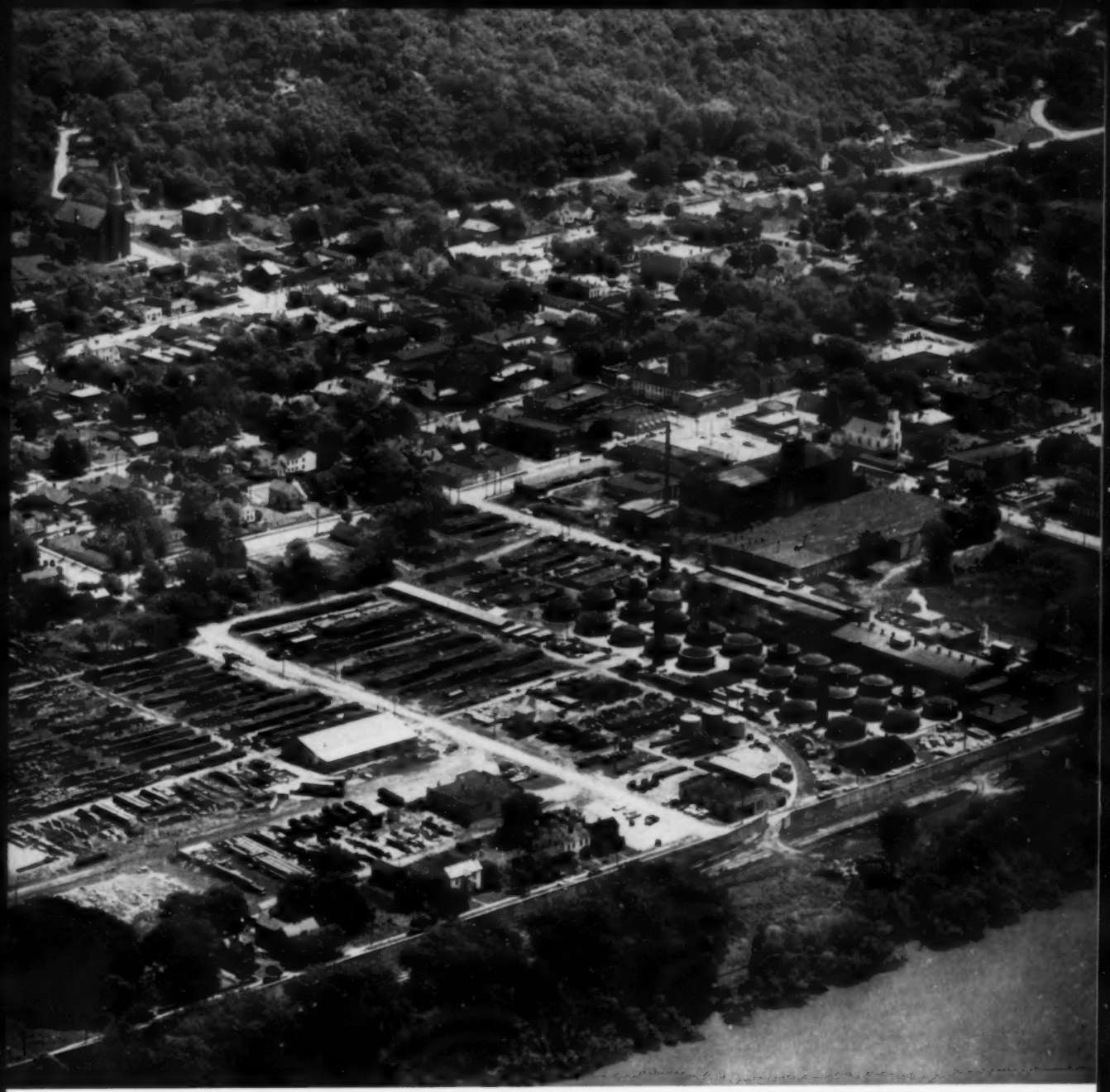
The Cannelton story began when Anthony and Henry Clemens organized the company on the basis of the availability of shale and fire clay in the Cannelton area. Located on the Ohio river the company in its early days had access to good transportation and a ready market in the booming Ohio river valley towns as well as the fast growing metropolitan areas north and south.

Early stoneware makers and primitive pipe plants had demonstrated the superior qualities of the local clays. However the Clemens brothers had no pipe manufacturing experience but came rather from a family devoted to retail trade. The two brothers relying on local investors for additional capital in addition to the amounts that they themselves could provide had a paid in capital of $52,000 and the founding company also had issued notes and bonds that had provided another $46,000. Major stockholders in addition to the Clemens were Henry Bosquet and John Meyer.

The cornerstone of the new plant was laid on November 25, 1908 and was accomplished with suitable speeches by the local politicians as well as the officials of the new company.

Cannelton turned out in mass for the cornerstone laying in November

While John Meyer was the first President and Henry Bosquet was Vice President of the infant enterprise, Anthony and Henry Clemens assumed the active management. When the new plant was completed and the first pipe made in August of 1909 the crew was made up of experienced men brought in from Ohio, but soon after most of this group fell



Aerial view of the Cannelton, Indiana plant show the large storage areas and the many buildings that have been added since the early days to house the new departments.

homesick and together with the superintendent left. The task of putting the plant into effective production was left to the founders of the company who were strangers to the production of clay pipe as well as being without prior experience in the conduct of any manufacturing business.

The lack of operating experience was not allowed to interfere with the first guiding principle of the company. "Sewer Pipe of Quality" was more than a slogan and the policy of the company was to deliver a stronger and better looking sewer pipe than was then generally available. This policy paid off when users recognized the attempt of the company to deliver premium products and sales boomed, the company became profitable and began to grow.

The original plant was typical of plants built at the turn of the century, a multi-story drier house also housed a steam press which served the plant.

Clay and shale was ground with a drypan and tempered in one of the two wet pans installed. Power was supplied by a steam engine and the dried house was heated with steam. In 1909 the plant started production with six round kilns. Soon, sales required additional capacity and within three years the kiln capacity was doubled. In 1915 additional kilns were

Please turn page

While early shipments were sometimes made by barge most went out by rail. Today trucks have replaced the railroad for most shipments.

built and in 1923 and 1924 the potential of the company was again doubled with the building of more kilns and drier space as well as necessary grinding and forming equipment.

At this time Cannelton again demonstrated its progressive outlook by installing equipment that would manufacture longer and larger pipe. Now they could make 36″ instead of being limited to 24″ and the maximum permissible length was doubled.

By strict attention to the control of costs and a policy of intense effort the company was able to weather the depression even though many of its contemporaries were being pulled down and liquidated by the pressure of the times. During the early years when demand had failed, production was stockpiled and when the demand for pipe was rising in 1933 with the increase in public works the overstocked yards were rapidly cleared and the company was able to maintain operations throughout the balance of the depressed years and was well-situated to take care of the boom caused by war construction in 1939 and 1940.

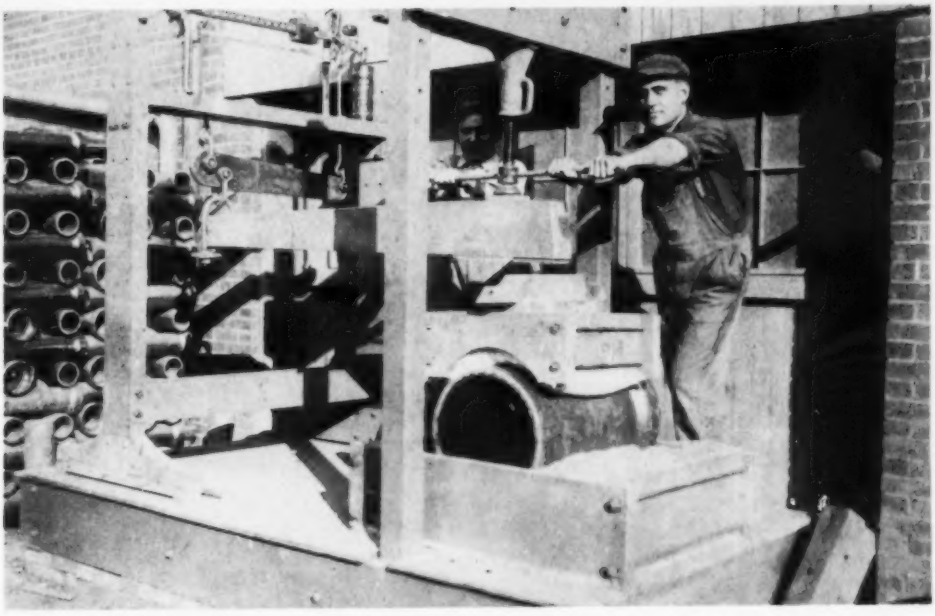
In 1946 the great increase in housing susperceded the war construction as the big consumer of clay pipe and all efforts were made to increase the efficiency and economy of the Cannelton plant. In 1954 the plant was

Eugene and Edward Clemens, Vice President and President of all of the associated Cannelton Companies.

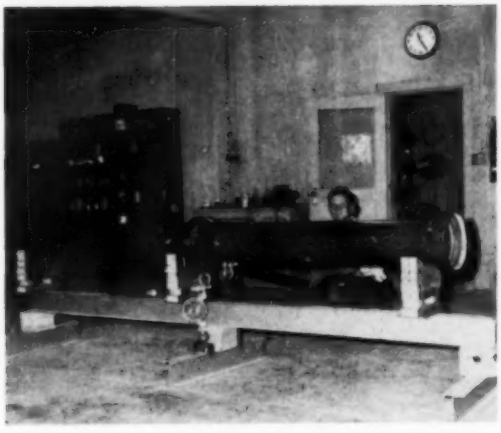
remodeled, old methods were examined and where indicated were supplanted with new equipment and techniques. This is a continuing program and improvements are still in progress.

Through the years horizontal extrusion was added to supplant the vertical press for production of smaller pipe sizes, drying capacity was increased with the installation of forced circulation and rack drying and the fork truck supplanted brute strength and pipe carts. Value was added to the companies' products by the installation of precast joints. A leader in this field the company today makes

An early experimenter with mechanization, Cannelton packages most shipments now.



Early test methods were crude by present day standards but did insure high quality standards.



Modern test for suitability of factory applied seals.

both asphalt and poly-vinyl-chloride joints in two modern joint plants. A substantial portion of the pipe shipped today have been jointed. While the company was growing up and changing with the times to meet each new challenge as it arose the delivery of pipe to the customer changed from rail and barge to the truck. Today the companies' trucks handle these functions. Cost again have been closely examined and Cannelton one of the pioneers in the use of the fork truck, loads all of its shipments with the use of mechanical equipment. By packaging pipe the shipping department has been able to cut costs, breakage and at the same time expedite delivery.

Through the years the company has considered three things to be of prime importance. Quality and service second to none has been the base on which the enterprise has been built.

But more important perhaps was the rule laid down by the founders: Know costs and make sure that all sales are made at a price that will return the cost and a little more.

The third consideration in the companies' policy was the essential need for people in the planned growth and advancement of the enterprise, to provide for the development of people and thereby to insure that the company will at all times be in a position to carry out the long term plans of growth and advancement.

These three guiding principles are implemented with a system of intercompany comunications. Regular staff meetings are held in addition to a weekly foremen's meeting to insure that all of management are aware of the current condition and problems.

A definite plan has been adopted to consider the problems and progress of the company in the fields of research and community relations and when needed meetings are held at which these important phases are discussed and explained.

Through the years research has played an important part in the accomplishment of the production of only pipe of the highest quality. In 1931 a laboratory was set up by the company to handle research and

Please turn page

product development and through the years this department has grown in scope at its value was proved. The original quality control on strength and absorption of finished pipe that was begun in 1909 has grown until today all raw materials are mapped and tested prior to their use in the plant.

The new products developed in the laboratory have in turn added to the work load of quality control. Today for example every lot of incoming plastic used for the research developed plastic joint is tested for its content of solvent, moisture and air as a matter of course. The flow at elevated temperatures, tensile strength, elongation, gel temperatures, viscosity, hardness and specific gravity are also checked to insure that quality of finished product is maintained. Every piece of pipe shipped from Cannelton bears a code number that indicates where the pipe was made and every person who was connected with its production from the pits through the plant and delivery.

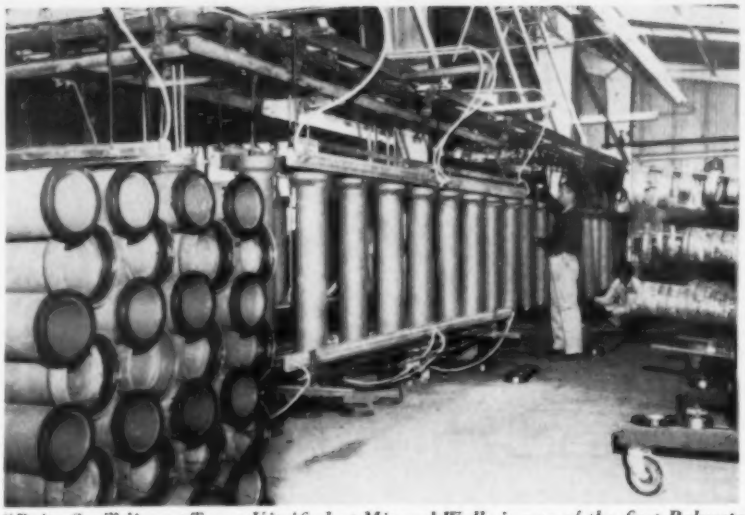
Such control insures that the policy of "Top Quality" is more than a mere slogan.

Market Study

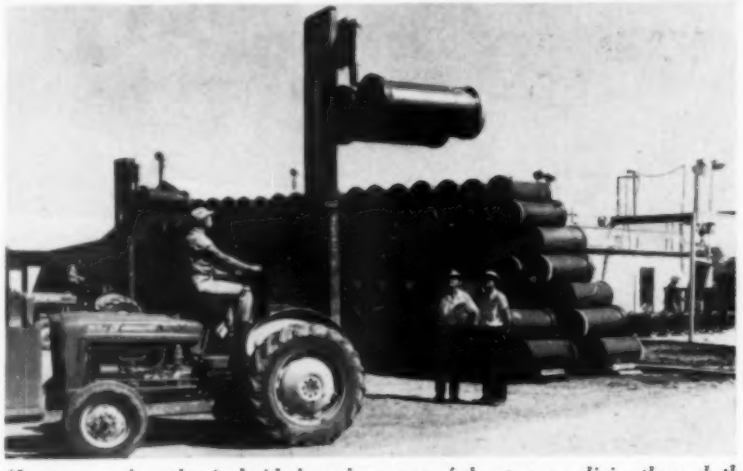
After the war in 1946 the management wishing to carry out the long-term policy of growth and progress made a study of the potential market for clay pipe and decided that on the basis of greatest potential the Southwest was the most logical market for added investment.

A subsidiary, The Texas Vitrified Pipe Co. was organized and a plant was built at Mineral Wells, Texas. Not only was Mineral Wells centrally located to several booming markets, but the local raw materials were well-suited to the manufacture of sewer pipe with modern machinery. Six periodic kilns and a tunnel kiln were built and the plant was equipped with modern grinding and handling equipment. Production started in 1949 at 20,000 tons per year rate. Immediately the investment was vindicated by a strong demand and almost at once original plans for expansions were put into action. Today the Texas plant has exceeded 55,000 tons in annual production and once again construction is underway to increase capacity.

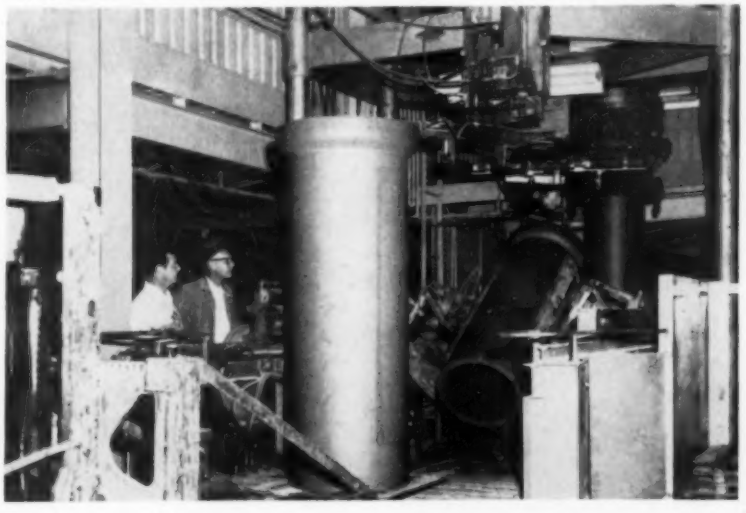
Texas Vitrified has pioneered the

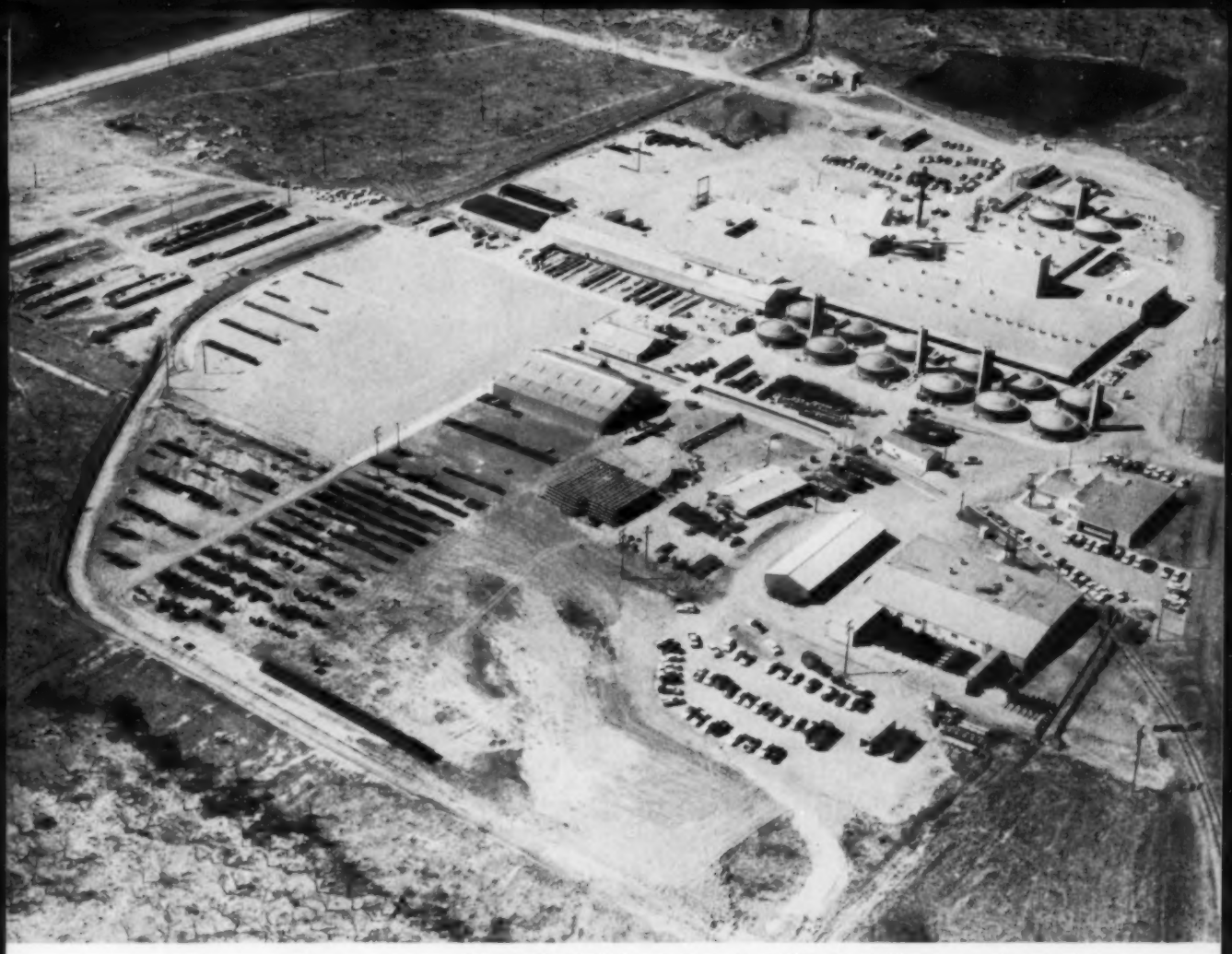


"Delta Seal" line at Texas Vitrified at Mineral Wells is one of the first Polyester resin joint lines.



***Above,** use of mechanical aids have been one of the strong policies through the development of the Co. **Below,** Pearne and Lacey forming and handling equipment has eliminated much hard difficult dirty work at all of three of the clay pipe plants.*





Texas Vitrified Pipe is located at Mineral Wells, Texas, plant in foreground is that of Southwestern Plastic Pipe Co.

production of unglazed pipe and was among the leaders in the development of poly-acetate resins for factory applied joints. Again research has paid off as the companies' "Delta Seal" joint has been selected by some municipalities as the standard for selection of factory seals. Production of the joint has boomed and expansion of the seal line is underway.

In 1952 The Texas Vitrified Pipe Co. organized a subsidiary to enter the plastic pipe business. This company, The Southwestern Plastic Pipe Co. has the same officers as Cannelton and Texas Vitrified Pipe Co. but is operated as an independent operation. The plastic pipe company has in a few short years become one of the leaders in several areas of plastic pipe sales. The Southwestern oil fields offer large markets for the products of this division. While one of the original thoughts behind the formation of this company was that developments in the plastic industry might someday make such materials economically useful for sewers in the smaller sizes the research and product development of the new company soon had products for electrical and communication conduit, irrigation systems, well casings, gas transmisison and oil field applications. An action taken as a hedge against the future has opened up a multitude of opportunities to a management used to expansion, seeped in the tradition of research and product development and well prepared to advance in a new field.

The latest expansion of Cannelton Sewer Pipe Co. operations was completed in 1958. The Owensboro Sewer Pipe Co. at Owensboro, Ky. located near Cannelton was acquired by the purchase of common stock. The original Owensboro plant was established even before Cannelton and was practically rebuilt in 1949 after much of the plant was destroyed by fire. The mill room is consequently among the most modern in the industry. Horizontal extrusion, automatic finishing and handling at Owensboro were among the first installed when this important technique was developed. Subsequent developments in manufacturing methods have been incorporated and the plant has maintained its effective performance. Methods of material and pipe handling developed at this plant have been adopted in many other plants as the superior methods have become known.

While operated as a separate entity like the Texas ventures the geographical location has permitted the operations of the Cannelton and Owensboro plants to be coordinated and the combined sales staff have been reorganized to bring an even

Please turn page

Owensboro Sewer Pipe Co., newest addition to Cannelton

higher standard of service to the consumers of the mid-states region.

Techniques of poly-vinyl-chloride jointing pioneered and proven at Cannelton have been installed at Owensboro since the plant was acquired.

Alfred Clemens, Cannelton Executive Oversees Owensboro Production

Management

Edward F. Clemens, President of Cannelton Sewer Pipe Co., Texas Vitrified Pipe Co., Southwestern Plastic Pipe Co., Owensboro Sewer Pipe Co.

Eugene C. Clemens, Vice President of Cannelton Sewer Pipe Co., Texas Vitrified Pipe Co., Southwestern Plastic Pipe Co., Owensboro Sewer Pipe Co.

Alfred H. Clemens, Secretary of Cannelton Sewer Pipe Co., Secretary and Production Manager of Owensboro Sewer Pipe Co., Treasurer of Texas Vitrified Pipe Co., Southwestern Plastic Pipe Co.

Norbert B. Honnigford, Treasurer of Cannelton Sewer Pipe Co.

E. G. Meisenheimer, Jr., Secretary of Owensboro P Sewer Pipe Co. and Office Manager

J. F. Bailey, Secretary of Texas Vitrified Pipe Co. and General Manager

Roger Stoen, Production Manager of Cannelton Sewer Pipe Co.

Arthur J. Clemens, Sales Manager of Cannelton Sewer Pipe Co.

E. W. Hendrick, General Manager of Southwestern Plastic Pipe Co.

Robert E. Blessing, Production Manager, Texas Vitrified Pipe Co.

David E. Clemens, Assistant General Manager, Texas Vitrified Pipe Co.

Don Kearby, Sales Manager, Texas Vitrified Pipe Co.

Russell E. Stevens, Controller, Texas Vitrified Pipe Co.

Top Block Breakage Cut With Petalite Additions

Kiln car tops and kiln furniture, based on a new ceramic body, may be an answer to the clay product industry's long-standing kiln maintenance problem.

Earlier this year, Robinson Clay Products announced the availability of two new heat-shock refractory compositions, designated as R100-19 and R100-27. Under test for two years, the new refractories are characterized by a low thermal expansion and hence excellent heat shock resistance. Robinson itself has equipped all the kiln cars at its Pottstown, Pa. Sewer Pipe plant with the new refractory and estimate that refractory life has been increased about ten-fold. Elsewhere within the companies' plants there has been a general switch to the new refractory for all applications where heat shock damage is a serious problem. All told, the company estimates that it is saving better than $80,000 per year on direct and indirect kiln maintenance costs.

Long Research Program

The new refractory is the result of five years work on the part of the company's research department at its Parral, Ohio plant. The new compositions are based on petalite—a ceramic material long known to impart thermal shock resistance. Robinson offers two compositions which differ with respect to load-bearing capacity and thermal expansion characteristics. Recommendations of one composition or the other depend upon conditions of use.

Innovations in design have also contributed to improvements in the thermal shock resistance of these kiln car tops and other heavy refractory pieces. The redesigned pieces are lighter, have more cores and in some instances are actually thinner in cross-section. The lighter refractories offer the added advantages of improving the efficiency of fuel consumption, since fewer B.T.U.'s are required to bring the kiln cars up to temperature.

New Concept

Research director, R. H. Anderson, says of the new refractory: "This is a new concept in refractory manufacture. In the past, refractories have usually been specified primarily on the basis of their PCE. Very seldom in ceramic manufacture is a high degree of refractoriness required. While a PCE of 32 might be specified the refractory probably operated at far lower temperature range, perhaps no higher than Cone 12.

"On the whole, resistance to heat shock has been a far greater problem than refractoriness per se. Petalite-based refractories are not highly refractory in the accepted sense. The two compositions which we offer have PCE's of 19 and 27 respectively. Nevertheless, they have high heat shock resistance and good resistance to deformation up to about 2300°F. Since most structural clay products are fired at a temperature below 2300°, we believe that these new refractory compositions are not only the best answer, but an available means by which kiln maintenance costs can be drastically reduced in the structural clay products industries."

Service to 2400

Actually, it was pointed out kiln car tops made of the new compositions are being used quite satisfactorily at temperatures as high as 2400° in over-fired kilns. Nevertheless, the company will not recommend its refractories for use above 2300° without an investigation of the kiln conditions. "Even then," says Anderson, "we would recommend the installation of a test car before guaranteeing satisfactory results."

So far, the company has been its own best customer. Its first major installation was its Pottstown plant and this has provided them with a dramatic case history. The Pottstown plant fires salt glazed sewer pipe on a 31 hour schedule—one of the fastest in the industry. Heat shock was naturally a severe problem and refractory life was short. Under this murderous schedule, kiln maintenance was running almost $3.00 per ton on the finished product, but the company felt this was warranted in view of fuel savings and other benefits which were obtained from the fast production schedule.

Refractory Costs Cut

"Petalite refractories have been termed a godsend. Kiln maintenance has dropped to less than $1.00 per ton—including the initial cost of replacement. Except for the fact we are salt glazing in this kiln and therefore have a problem of glazing in connection with car tops, I believe that they would virtually never wear out."

This contention is being borne out by experience at Clay City Pipe Co. in Uhrichville, Ohio. Here a short kiln and a fast firing cycle raised havoc with kiln refractories until they were replaced with Robinson R-19 block. In service for over a year, they show no signs of deterioration. Robinson is also supplying Clay City with special setter rings for sewer pipe. "Before we knew of petalite bodies." says Anderson, "it was impractical to make special setter rings. However, they have proven very satisfactory at Clay City and the only loss encountered to date has been due to mechanical breakage rather than thermal shock. The additional cost of a petalite re-

Continued on page 84

Athens Blends Five Clays to Make Buff, Red and Black

Clay blending, designed to control the color of the fired brick and at the same time to retain identical maturing temperatures, high lights production at the Athens Brick Co. in Athens, Texas. Five different clays, each selected for particular properties of color effect and refractoryness are taken from the four pits operated by the mining division of the company.

Texas weather requires that clay intended for use during wet winter and spring months be taken from the pits and stored in well drained piles during dry periods. Open storage is satisfactory and most all of the clays are stacked near the grinding area after being taken from one of the pits with a Byers ¾ yard dragline and hauled to the plant with dump trucks.

Ground Clay Storage

Material required to replenish the preliminary ground clay storage bins is taken from the storage piles with a front end loader and loaded into one of two dump trucks which move the material to a hydraulic operated reciprocating feeder. A short belt conveyor moves the raw clay to a Miller disintegrator which makes the initial size reduction. From this station the clay is moved on a 24" belt to the center line of a storage shed where the clay is discharged onto a belt running from the elevating belt to the shuttle located in the dog house on top of the clay storage shed. The clay storage shed is 90 x 140 feet and when completely full holds enough clay for 60 days production. The nature of Northern Texas clays and long periods of wet weather require such storage capacity as a minimum condition.

Transportation of preliminary prepared clay from the storage area to the final grinding operation has been held to a minimum with the installation of the feeding and grinding machinery in the same building as the storage piles. Clay required for production is taken from the proper bin with the front end loader, a AC H-D 6 and placed into one of three bins. Two of these are used for clay and the other is used to add bats and other grog material to the mix for those blends that require the addition of hard material for proper processing. The clay bins are served with belt feeders operating at a fixed speed and the grog bin is served with an apron feeder. Clay percentages are controlled by changing the depth of the clay on the feeding belts.

Blend in Grinder

Maximum blending of the different parts of the mixture is obtained by grinding the mixed batch with a Miller hammer mill. This unit powered with two 30 horse motors is heated with gas jets to prevent build up of the very plastic clays that are used in much of the production at Athens. All material discharged from the hammer mill is elevated with belt conveyor to a pair of Overstrom screens. These units, heated and vibrated, return oversize to the hammer mill circuit and the fines are passed to a conveyor which moves and elevates the ground and blended clay to the prepared clay storage silos.

The conveying system is designed to empty into either of two steel tanks. These hold enough material for 30,000 brick each and together when full hold almost enough material for one days run in the mill room. By using two bins the grinding department can work ahead of the mill room when preparing a new produced mixture of clays for one of the many different colors at the plant.

Each of the storage tanks has been equipped with a belt feeder adjustable as to the height of the clay on the belts. A short conveyor carries the material being used directly to the mill room and dumps it into the pug section of a Steele 40. The mill room is straight forward, water is added at tap pressure and production is at a 10,500 brick an hour rate with the brick being cut on an #18 cutter. Dies are oil lubricated and the pug-extruder combination is driven with 150 horse. Only two men are stationed in the forming area, a brick machine tender and his helper. Die changes and reel changes on the cutter are facilitated with overhead rail and hoist.

75,000 Brick A Day

The off-bearing belt at Athens Brick passes through a connecting shed to the hacking station. This station is located at the midpoint of the tunnel kiln and empty kiln cars pass under the belt on two hacking tracks. Four off-bearers are used to handle the daily mill-room production of 75,000 brick which allows a backlog to be built up for Saturday and Sunday when the plant with the exception of the kiln is shut down.

Brick are set fourteen courses high on the cars in regular courses and a fifteenth partial course crowns the kiln load. The cars are nine foot six inches by seven foot two inches wide. The setting is eight brick wide and the bottom brick are edge set with no difficulty experienced in firing these. The holding tracks are conditioned with air drawn from the dry end of the dryer and when needed, supplemental heat from space burners. The holding track housing has been extended into the off-bearing area proper, as it was found that dry air drawn through the setting while the car was being set was enough to cause damage to the green brick. When all

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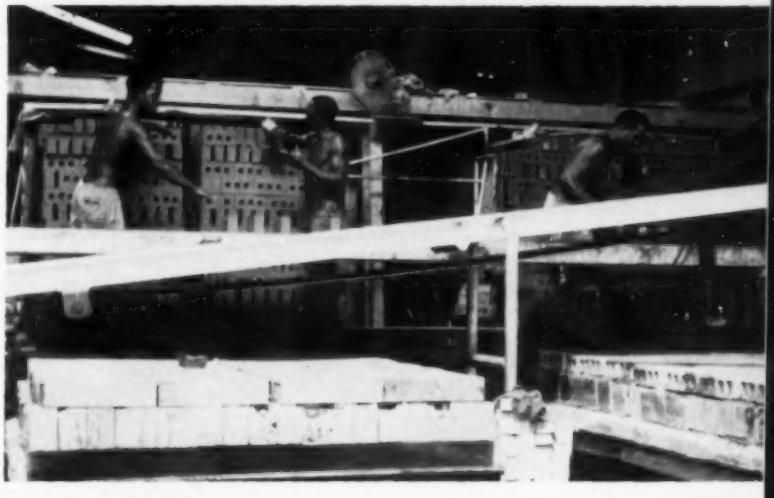
Clay moves from preliminary grinder to clay storage shed on pictured belt system.



Loaded tunnel kiln cars are protected from drying air as soon as is practical after loading.

One of two grading and sorting lines handling a total of 75,000 brick a day at Athens.

Structural Division Hears of New Products at Alfred U. Meeting

New designs, new products and solid data on the structural clay industries clay bonded lightweight aggregate block were some of the highlights of the Division meeting of the American Ceramic Society at Alfred University. The three day meeting held on September 10 through the 12th also saw several papers covering technical approaches to some of the more pressing problems facing the industry today. Over 100 members also attended the social affairs held.

Philip Caruso, Swindell Dressler Corp. presented a paper on "Lightweight Clay Products". He brought out that the paper was a report on work by his company investigating the basic engineering data for the design of kilns and driers specially for the all clay unit.*

Design Papers

The other two papers presented on the general subject of lightweight aggregate and clay products were presented by members of Alfred University. Billeci and Ekdahl collaborated on the presentation of "New Designs For Structural Clay Products" and L. Washburn outlined a series of new products that have been developed from a bloated New York state shale. The first of these papers dealt heavily with the values that can be added to any product by the designer. These were described as values that appeal to the senses of the consumer and most important. The lightweight aggregate approach was described as being very appealing. Washburn described the processes involved in developing a new clay block unit for a public housing project.

The field trip was taken on Thursday, the tenth, with a bus trip to the Corning Glass Center at Corning, New York. Here members were able to view objects on display in the Glass Museum and could observe the production of Steubin Glassware.

New Kiln

Included on the program was a demonstration of a roller kiln designed at Alfred. This unit was connected with a laboratory size extruder and a continuous dryer also developed at the school, and during the demonstration produced miniature size hollow tile on an automated basis. Transfer of tile from extruder to drier to kiln was completely mechanical and ware was carried through the kiln on refractory rollers installed much like a standard roller conveyor. The demonstration was under the direction of Leon B. Coffin who was instrumental in the development of the kiln.

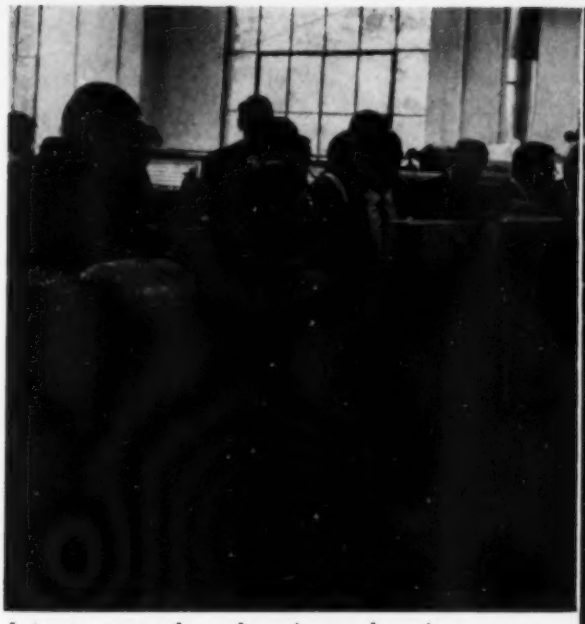
A report was made by Dr. Wayne Brownell regarding the Vanadium efflorescense work under way at the Alfred school. According to Brownell, vanadium compounds of a basic nature are colorless and therefore are not suspect in the green stain problem. However, acid vanadium compounds do have the green color and it was suggested that since practically all brick clays tested have some vanadium present that the acid condition is a prerequisite in the development of such problems.

Basic Techniques

A strong program of basic techniques was presented

In view of the timeliness of this paper and the potential value to our readers, it is being presented in its complete form in this issue. The paper begins on page 69.

Crowd listens attentively at meeting



Laboratory extruder and continuous dryer in operation at Alfred. Picture on right is of roller kiln that was used in connection with dryer drier to make a complete automated system.

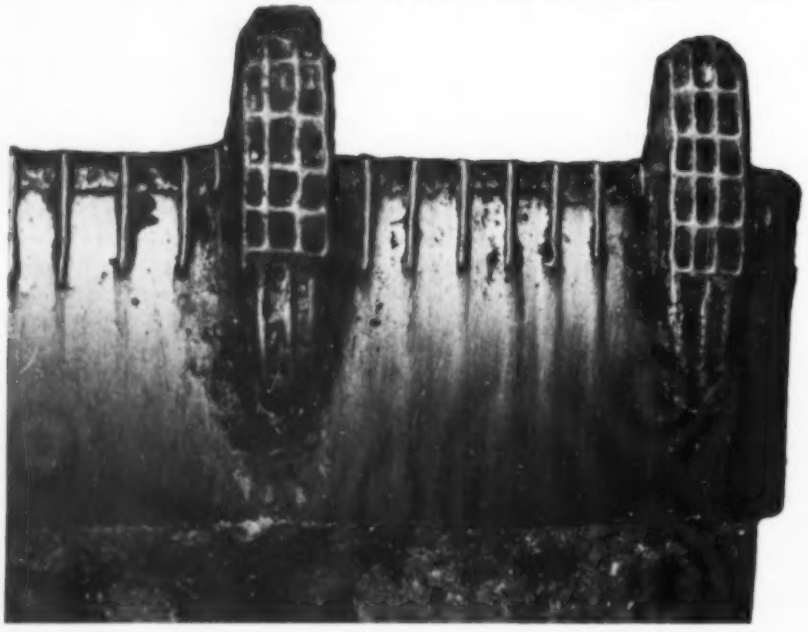
to the meeting. Demonstration of X-Ray diffraction, differential thermal analysis and Plastograph methods of clay study was backed up by a paper by D. E. Rase of Alfred on "Phase Diagrams and Nonequilibrium Conditions", a discussion on a "Study of Crystalline and Glassy Phases in Commercially Fired Brick", by P. Hedges of Harbison-Walker and "Identification of Clay Minerals as Applied to Structural Clay Products" by H. H. Murray of the Georgia Kaolin Co.

It was announced that the next division meeting would be held in October of 1960 at French Lick, Ind. The tentative subjects for which papers are solicited are: Manufacturers' experience with additives and Combustion and Clay Mineralogy.

Clay bonded block some fired on Swindell-Dresslers program were displayed at the meeting in Alfred's kiln room on the cars where they were fired.

A few passes of STOODY BOROD...

and you can forget Scoop Wear!



The scoop in the photographs above has been in constant use for 18 months without further attention. Note at left amount of hard-facing material still remaining from first application.

Scoop lips and teeth are natural targets for abrasive wear. The scuffing over hard surfaces picking up load after load of earth, sand, clay and other abrasive materials eats away edges, dulls both the lip and the teeth.

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APPLICATION DATA

Apply single stringers of Borod on top sides of teeth and scoop bucket lips. Make a continuous pass along under edge of lip and add stringers at right angles extending back 2 to 3". A cross-hatch pattern on under side of teeth adds protection in cases of severe abrasion. Greater wear resistance is obtained from oxy-acetylene applications but electric arc can also be used.

STOODY COMPANY

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New Design Data for Clay Bonded Block

by
Philip A. Caruso

This material was presented by Philip Caruso at the Annual Structural Products Division gathering of the American Ceramic Society at Alfred University recently. It reflects the basic investigations being conducted by his company, Swindell-Dressler of Pittsburgh, into the requirements of processing clay bonded aggregate products. Its use in this issue was made possible by the courtesy and cooperation of the author and the personnel of The American Ceramic Society.

Early this year Swindell-Dressler Corp., Pittsburgh, Pa., decided upon a program of investigation and development with lightweight structural clay products. At that time published information of the type required for our work seemed generally lacking.

As we became more familiar with this new and promising family of products, it was further decided to concentrate our effects on various lightweight clay block. We would rely on the research agency working with the extrusion of mixes using the new SCR aggregate to inform us on this technique. We also felt that the people doing development work with the lightweight aggregate vermiculite would make available their findings.

Two Markets

The recapture of some of the market lost to concrete block appeared a possibility. This fired clay block—assuming that gross compressive strength requirements could be met—was inherently a better unit as to such important in-the-wall requirements as water absorption, linear thermal expansion, and linear drying shrinkage. It had promise as an inexpensive fire wall. Lightweight clay block also found a gap to fill as structural clay facing units.

In our development program with lightweight block the following objectives served as a guide:

1. Familiarization with the various aggregates, mixes, mixing procedures, and forming techniques in order to make the proper plant process equipment selection.
2. Realization of data for the design of special kilns and dryers.
3. Determination of requirements for good process flow, equipment arrangement and general plant layout.
4. Compilation of information for plant and product costs.

Various aggregates, bonding clays and shales, and additives were made available to us. We had access to a leading research center and the plant of a concrete block manufacturer doing extensive development with lightweight clay block. Firings were conducted here at Alfred University under the direction of Professor Richard West.

Aggregate graduation and the matching of aggregates and bonding materials for maturing temperature were generally established by the supplier. Aggregates representative of all available types were used during some phase of the program. One expanded shale aggregate became rather tricky. It displayed violent

Continued on page 71

DRY PRESSING DATA

PER CENT HAYDITE	PER CENT SCR	PER CENT CLAY	PER CENT MOISTURE	SILICANIT ADDITIVE	PRESSURE RANGE, psi	COMPRESSION RATIO	RECOMMENDED PRESSURE	REMARKS
80	——	20	4.4	None	1000 to 2200	1.75 : 1	1500 psi	Poor wet green strength below 1700 psi
80	——	20	4.9	1%	1000 to 2000	1.55 : 1	1500 psi	Good wet green strength
80	——	20	5.3	2%	1000 to 2000	1.50 : 1	1500 psi	Good wet green strength
80	——	20	13.8	None	1000 to 2000	1.80 : 1	1000 psi	Excellent wet green strength
——	65	35	6.8	None	500 to 1000	2.50 : 1	5 600 psi	Excellent wet green strength
——	50	50	4.8	1%	500 to 1000	2.10 : 1	5-600 psi	Excellent wet green strength

(Figure 1)

PNEUMATIC IMPACT PRESSING DATA

BATCH	PER CENT HAYDITE	PER CENT SCR	PER CENT CLAY	PER CENT MOISTURE	SILICANIT ADDITIVE	IMPACT TIME (SEC.)	COMPACTION RATIO	REMARKS
1	80		20	6	1%	10	2.06 : 1	Edges crumbly Strength only fair
2	80		20	6	1%	15	2.13 : 1	Edges sharp Strength good
3		50	50	6	1%	15	2.66 : 1	Edges sharp Strength good

(Figure 2)

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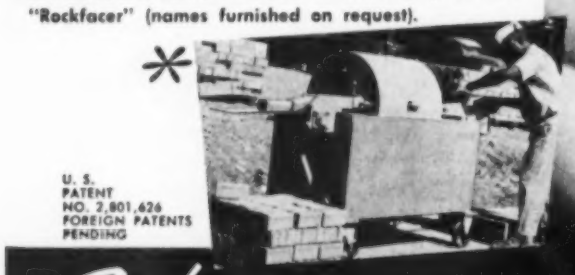

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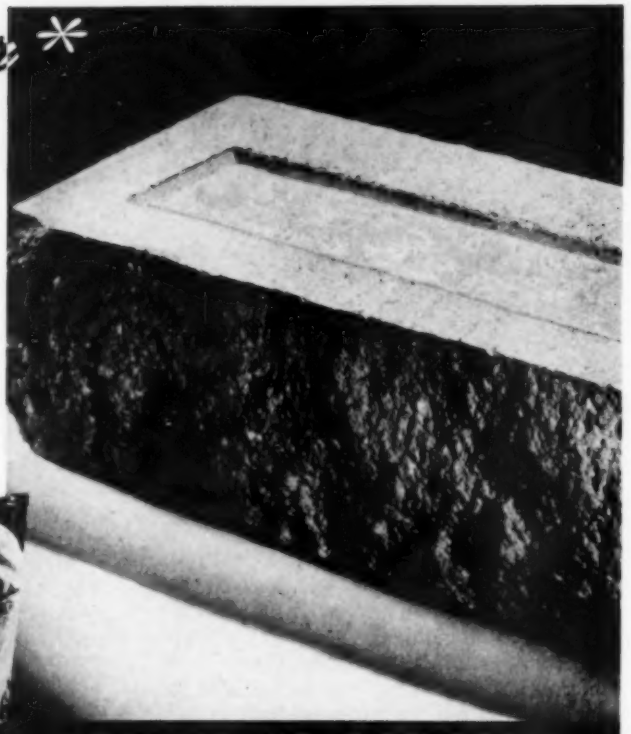

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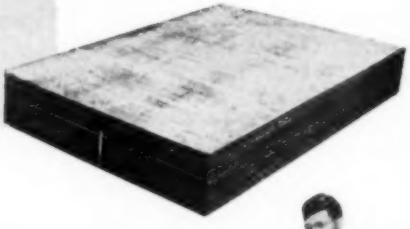

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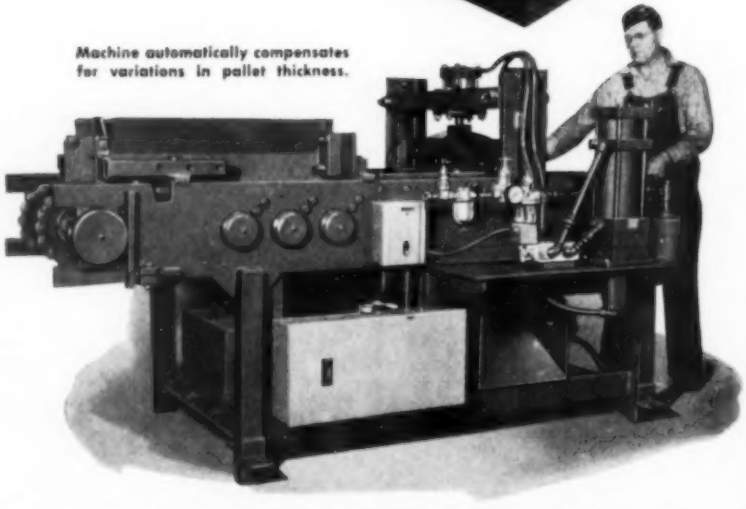

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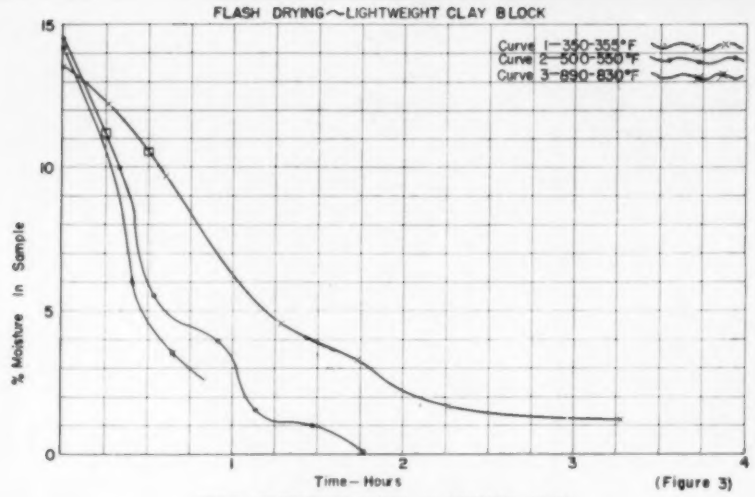
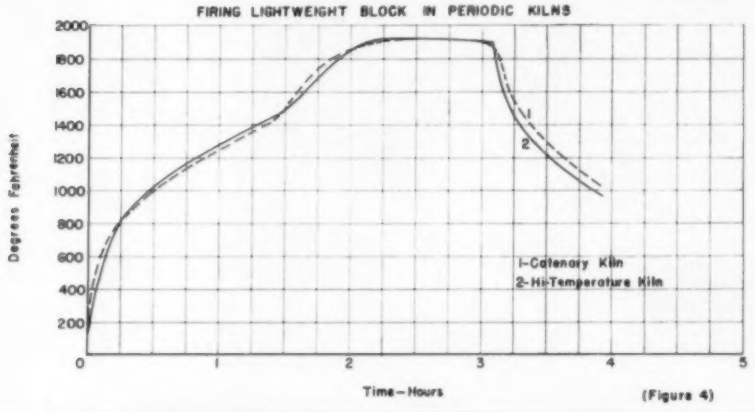


(Figure 3)



(Figure 4)

Continued from page 69

popping around 700-800°F due to residual stresses placed during water quenching and had to be "stress relieved" in our electric annealing furnace prior to use.

Dry And Slurry Mixes

Various type mixers were used in preparing batches for subsequent forming, drying and firing tests. Both the dry batch and slurry methods of mixing were tried and investigated. The following observations were made:

1. Mixes for dry pressing and pneumatic impact pressing must be prepared by the dry batch method. Aggregate and ground clays or shales should be thoroughly dry mixed before the addition of water to minimize balling. Water should be metered slowly.
2. Generally mixes for vibration compaction contain ample water for the slurry method. We found one clay, how-

Continued on page 72

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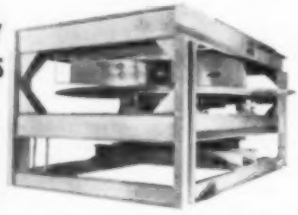

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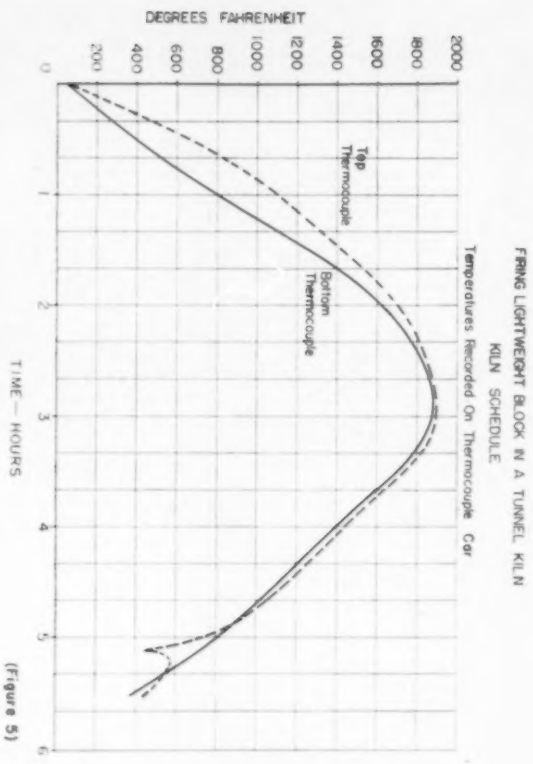


FIRING LIGHTWEIGHT BLOCK IN A TUNNEL KILN
KILN SCHEDULE
Temperatures Recorded On Thermocouple Car
(Figure 5)

ever, which was the exception. Tests should be made to determine the feasibility of the slurry method. About 1% sodium silicate greatly decreases viscosity.

3. Both ribbon and circular mixers were used. All were effective. The mullers, in muller type circular mixers, should be suspended clear to utilize kneading action without seriously affecting aggregate gradation.

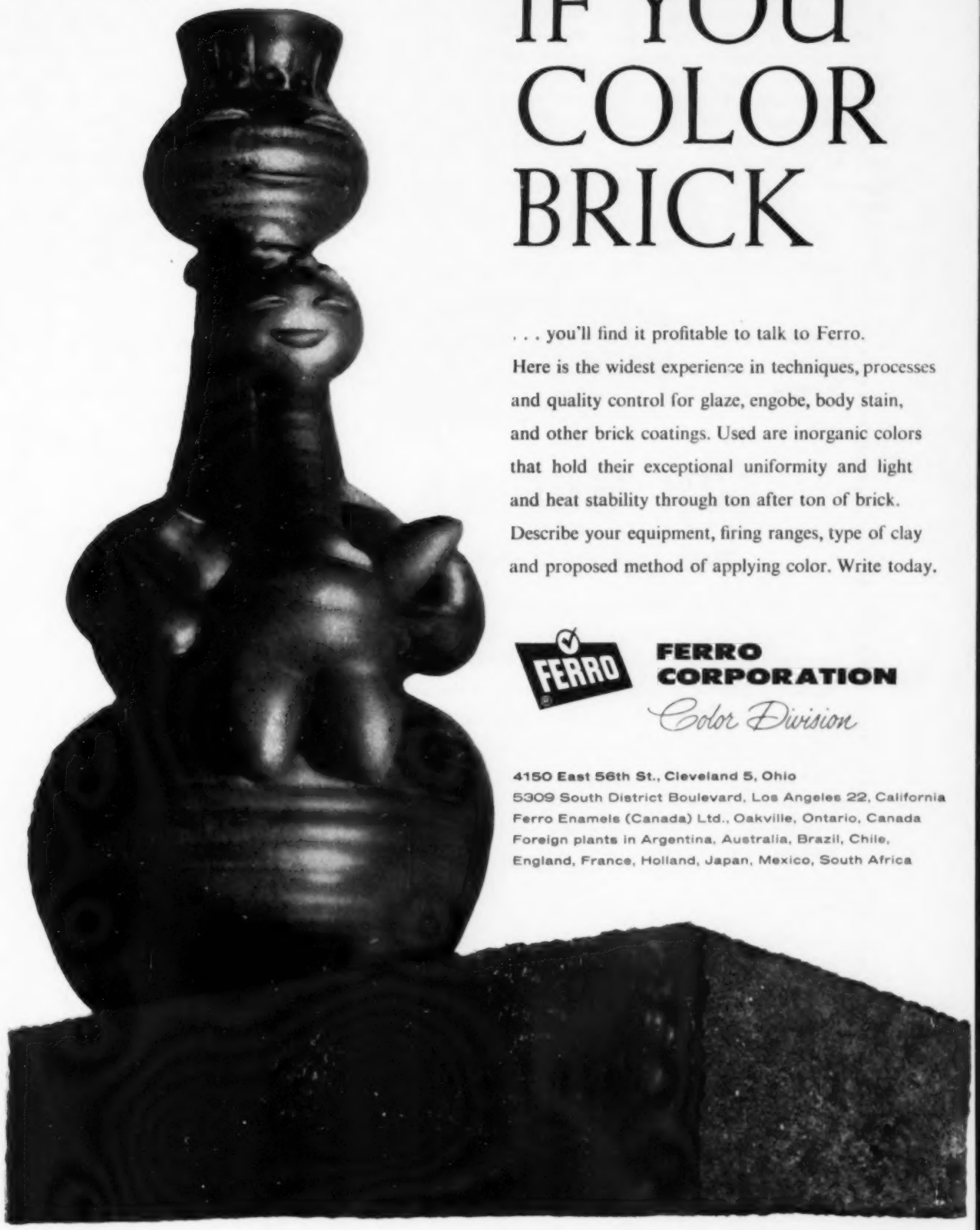
4. Three to five minutes of mixing appear adequate.

In our work we have had experience with the following methods of forming:

1. Vibration compaction by concrete block machine.
2. Hydraulic dry pressing.
3. Pneumatic impact pressing.

Certain phases of our program have been conducted in cooperation with a leading manufacturer of concrete and structural clay products. We have observed several of their clay block runs and have had seven of our mixes vibration compacted

Continued on page 74



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Continued from page 72

into two-core 8 x 8 x 16 block on one of their concrete block machines.

Aggregates representative of the various types available, when properly blended with shales or clays and properly tempered with water, can be vibration compacted into well-textured, sharp-featured block. An 80-20 mix, by weight, of expanded-shale aggregate and ground shale, with about 16% water, forms a good block. A 50-50 mix, by weight, of SCR aggregate and ground shale also makes a good block. Water content is a low 8.7%—typical of impervious glossy aggregates. Water requirements are critical, but a capable machine operator can handle moderate variations. Output rates comparable to concrete block production are possible.

Mixes containing high percentages of clays or shales are tacky, tend to ball up in the mold feed box and have poor mold release properties. Additives to improve dry green strength seem to be a necessity. The block as discharged from the machine on flat steel pallets have little wet green strength. These solid pallets impede air circulation during drying.

The phases of this investigation relative to hydraulic dry pressing and pneumatic impact pressing were conducted at the research center of a large refractories company. The test results are generally tabulated on the attached charts headed "Dry Pressing Data" (Figure 1) and "Pneumatic Impact Pressing Data" (Figure 2).

Dry Pressing

In running the dry press tests we were especially interested in pressure requirements, moisture needs and its effects, ratio of loose to compacted fill and wet green strength. Other observations include:

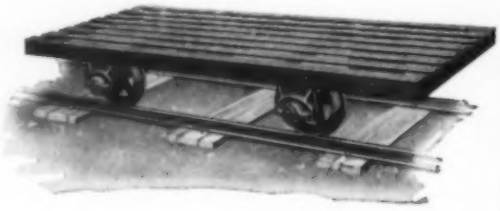
1. Expanded shale aggregates and ground clay or shale mixes tend to segregate during feeding. This places strict design requirements on feed mechanism. Sharp corners and edges may be difficult to obtain and hold even with aggregate gradations of 3/16" x 0. The dry pressing of quality lightweight clay block from mixes containing this type aggregate is problematical.
2. Mixes containing SCR aggregate form well at low pressures. This hollow spherical aggregate fractures and crushes at pressures as low as 500 psi. The sides of the test brick varied in appearance from smooth near the top and bottom to a textured band about mid-way.

Impact Pressing

The pneumatic impact press is of special interest because it combines the low moisture requirements of dry pressing with the textured appearance of vibration compaction. The data shows a compaction ratio for impact

Continued on page 78

whatever your needs . . .



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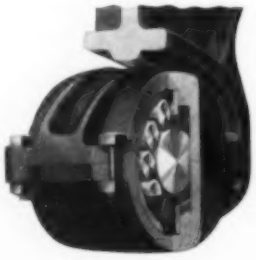

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KILNS—Payne Brick Co., of Texas, is now using a new 274' Swindell-Dressler Multi-Burner tunnel kiln. Preheating and oxidizing problems of their material are handled by atmospheric recirculation and excess air type burners. Kiln has a total of 72 burners, divided into 6 groups for control. Swindell-Dressler Corp.

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ORTON CONES—More uniform ware can be had with use of these cones. They can be placed throughout the setting to provide a visual check on the ware during the critical high fire stage; indicate end point of firing; show distribution of heat throughout the ware. Edw. Orton Jr., Ceramic Foundation.

46/Circle on Reader's Service Coupon

INTERNATIONAL—Brick machines have adaptability to produce good product whether you're making brick, refractories, cored block, pipe, tile or special shapes, with machines that can save up to 25% in power cost alone. International Clay Machinery Co.

47/Circle on Reader's Service Coupon

BRICK SORTER—Superior makes a brick sorter that can sort brick by any dimension, into any number of groups desired. Handles up to 3,000 brick per hour. Superior Supply Service Inc.

48/Circle on Reader's Service Coupon

BINDERS—Glutrin (liquid) or Goulac (powder) can help increase molding and dry strength of brick, clay refractories, pipe, tile, and other clay products. Small amounts required—easy to use. Robeson Process Co.

49/Circle on Reader's Service Coupon

SCREEN SECTIONS—Tyler screen sections are made for all makes of vibrating screens in any mesh or metal; made with hook-strip or bent-edge construction to suit your machine. W. S. Tyler Co.

50/Circle on Reader's Service Coupon

CRUSHING COSTS—Reportedly can be cut in half with use of Williams heavy duty hammer mills. Machine can finish grind bank run clays and shale in single operation, including hard lime particles, iron pebbles, tailings. Said to save up to 75% of capital investment. Williams Patent Crusher & Pulverizer Co.

51/Circle on Reader's Service Coupon

INVENTORY SCALE—A new totalizing scale by Thayer fits over any conveyor, continuously weighs material passing through. Can be used on level or inclined conveyors. New plate leverage system is guaranteed for the life of the scale. Thayer Scale Corp.

52/Circle on Reader's Service Coupon

STANLEY TIGHTENERS—The new O tightener is said to operate with ease and speed in any position; use fewer strokes for takeup, reduce operator fatigue. Manually operated tool has unlimited takeup, has two holding pawls on tensioning wheels. Stanley Steel Strapping Co.

53/Circle on Reader's Service Coupon

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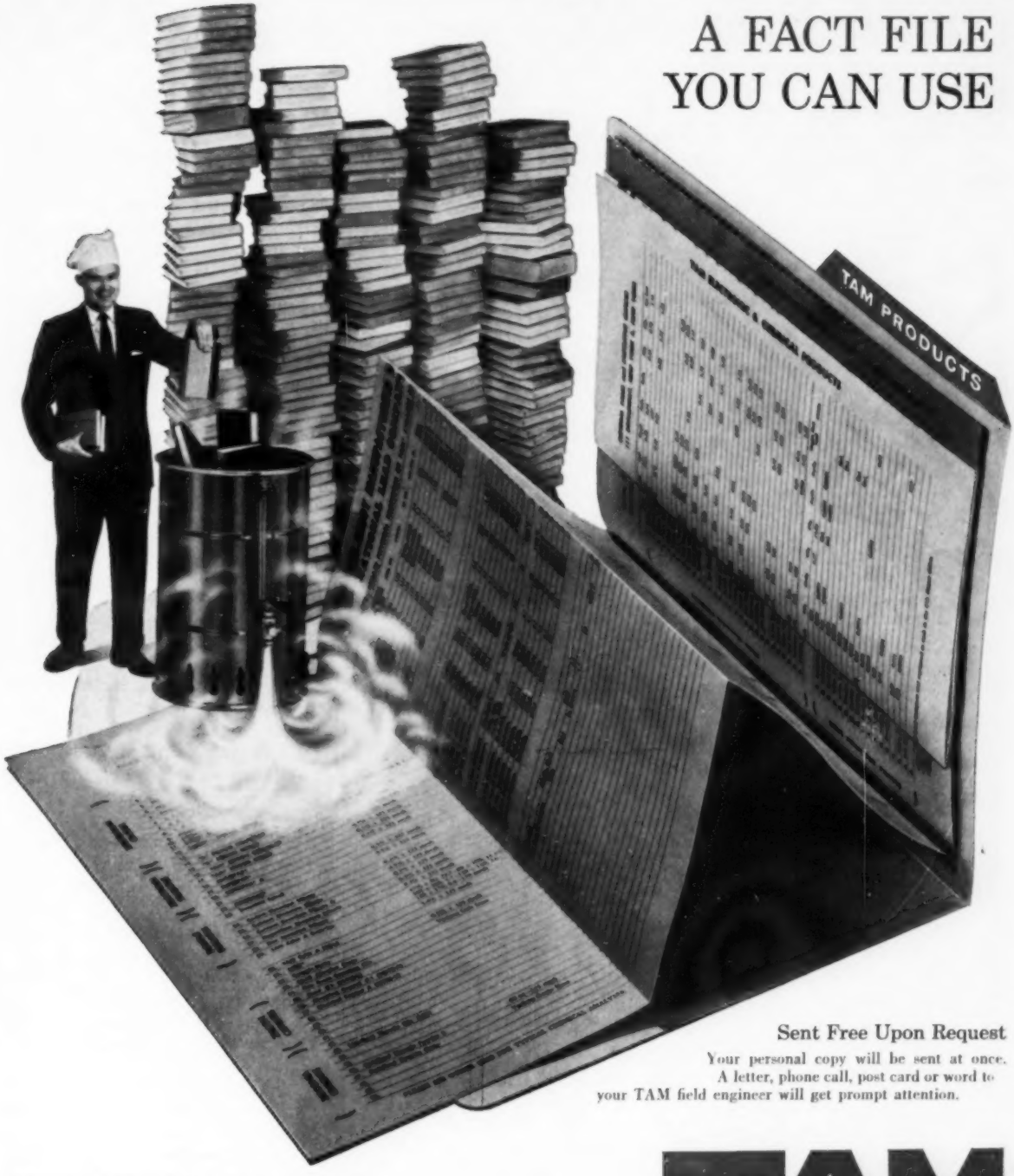

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Continued from page 74

pressing greater than dry pressing. A 15 second impact time would allow about three cycles per minute. Two block minimum per cycle would be necessary to get any production from the press. This type equipment deserves further investigation.

Several drying tests were carried out to determine:

1. Minimum drying time to acquire dry green strength for handling.
2. Maximum abrupt exposure temperature.
3. Whether or not, a conditioning zone would be required in a block dryer.
4. The possibility of firing block directly from the forming operation.

Fast Drying

Three vibration compacted block were subjected to drying atmospheres of 350-355°F, 500-550°F and 830-890°F to determine the rate of flash drying and the effects of such temperature atmospheres. The time-moisture relationships are plotted on the attached curves headed "Flash Drying—Lightweight Clay Block" (Figure 3). About 1¼ hours are indicated at 350°F to reach 5% moisture, the point where dry green strength capable of three-high stacking has been obtained. With the temperature at 500°F, about 45 minutes are required. These are essentially still air tests so these rates can be improved with good air movement. Flash drying at 830°F results in excessive popping and isn't advisable. No conditioning zone of high humidity would be required in a clay block drier.

Combined Drying and Firing

The first series of firing tests at Alfred University included two combined drying-firing runs in the Hi-Temperature kiln. Again referring to the chart "Dry Pressing Data" (Figure 1) moisture contents of up to 13.8% for expanded shale aggregate mixes and 6.8% for SCR aggregate mixes can be noted. These moistures were preserved since the test shapes involved were sealed in plastic bags right after pressing. These test shapes at moisture contents noted were placed into the kiln and exposed to the temperature rise indicated by the time-temperature curve #2 on the firing curves attached, titled "Firing Lightweight Block in Periodic Kilns" (Figure 4). It can be noted that a temperature of 800°F was reached in about 15 minutes. Some surface popping occurred on the Haydite-type aggregate test units but it wasn't too excessive. This test series indicates that direct firing from dry pressing, and possibly impact pressing is feasible. Glazed units, however, must be at least tentatively noted as an exception.

The initial firing tests were run in periodic kilns and the second series in a Dressler Unifab continuous kiln. These firings were conducted to obtain the following information:

1. Feasibility of firing direct from certain forming operations.
2. Effects of fast firing and special requirements in preheat and cooling.

Continued on page 80

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More Trade News . . .

Ohio Plant Selected For Floor Tile Plant

Johns-Manville Corp. will build a multi-million dollar plant near Chillicothe, for the manufacture of vinyl and asphalt floor tiles. The company said work will start at once with the plant to be completed by next summer. It will employ about 125 people.

McLain Nine Car Fights Deep Fires

McLain Works, Refractories Division H. K. Porter Co. Inc., has designed and built a Nine Water Car, which is very effective in fighting and bringing under control fires in deep clay mines. At McLain's six clay mines, miners are naturally alert to the possibility of a fire. Once started, clay mine fires are very difficult to bring under control, because seams of coal are usually coincident with good fire clays found in this area. Thus, fires can spread over large areas. Fire fighters must control air in the mine and the hazard of carbon monoxide from such fires is extremely great.

Mounted on a set of car wheels, printed red and lettered "fire" in white letters, the special car can be readily removed by the locomotive to the scene of the fire. At this point, an electrically powered pump installed on the water car can be plugged into the locomotive's battery and a full stream of water is delivered. (Main power lines are often knocked out in the event of fire.) A battery operated pump circumvents this and permits access to areas in which there is no power available.

Installs Another Kiln

The Southern Brick Co. of Ninety Six, S. C. recently installed a second Harrop kiln-325' with twin tunnel dryer, gas fired. They also added a Steele vacuum pug combination brick machine. Production is now 150 thousand brick per day at the tunnel kiln plant.

Changes of Address

If you're due to change your address, be sure to avoid missing an issue of B&CR. Please notify us of your new address at least six weeks in advance of moving date. Write: BRICK & CLAY RECORD, 5 South Wabash Ave., Chicago 3, Ill. Be sure to give both old and new address, zone number, and your name.

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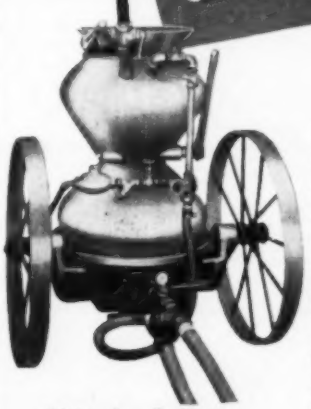

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Continued from page 78

3. Time-temperature curve data for the design of a car type kiln and a roller hearth kiln.
4. Design data for kiln car tops.
5. Determination of the effect of a roller hearth at the contact points on the block.
6. Position data to select the best method of placing block.

For the initial firings 9" x 4½" x 1½" test brick shapes formed by dry pressing from Haydite-type aggregate mixes and SCR aggregate mixes were fired on the 9" x 1½" edge placed across the hi-temperature Remmey periodic kiln. Two-cored 8 x 8 x 16 block were fired upright in the catenary periodic kiln with cores lined across the kiln. The time-temperature curves for typical firings for each kiln are indicated on the sheet of curves attached headed "Firing Lightweight Block in Periodic Kilns" (Figure 4).

The results from these periodic firings were summarized as follows:

1. A strongly oxidizing amtosphere is required to prevent bloating of the bond clay.
2. Fast cycles of four to six hours appear feasible.
3. Further firing tests in a continuous kiln are indicated.

Tunnel Kiln Firing

Two continuous firing runs were made through the Dressler Unifab kiln in the second firing series. Kiln car loads generally consisted of four two-cored 8 x 8 x 16 block in two courses. Some 8" SCR lightweight extruded building brick and 4 x 8 x 16 three cored dry pressed block containing vermiculite were also fired. The 8 x 8 x 16 block were formed by vibration compaction from both expanded shale aggregate mixes and SCR aggregate mixes.

The first firing was conducted on a 5 hour—40 minute schedule, a top firing temperature of 1922°F and 50% excess air (7-8% CO_2). The second run was slightly faster, with a maximum temperature of 1890°F and slightly less excess air (6-7% CO_2). Once the loaded kiln cars cleared the furnace zone on the second run, the gas was shut off and pusher stopped to simulate extended cooling. Various kiln cars were loaded especially to gain data for kiln car top design, roller hearth kiln design and block loading positions.

The attached time-temperature curves titled "Firing Lightweight Block in a Tunnel Kiln" (Figure 5) show temperatures recorded by the dual-thermocouple car on the second kiln run. The next curve headed "Proposed Firing Curve-Lightweight Clay Block" (Figure 6) gives a proposed tunnel kiln curve for block firing.

The following conclusions resulted from the second firing series:

1. Block may be fired on a six hour schedule providing the tunnel kiln maintains an even heat through the load.
2. A firing cycle shorter than six hours may be impractical because of the low initial heat rate, extended soaking and reasonable cooling period to prevent residual stresses.

Continued on page 87

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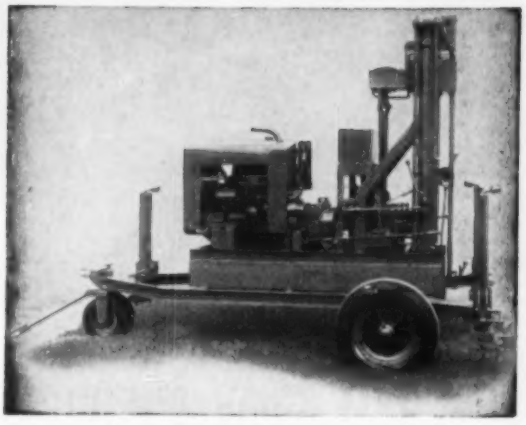

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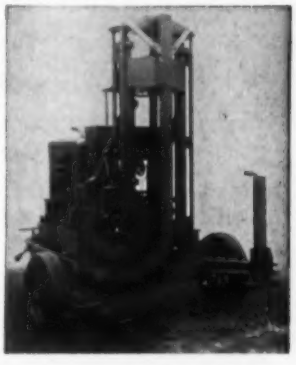

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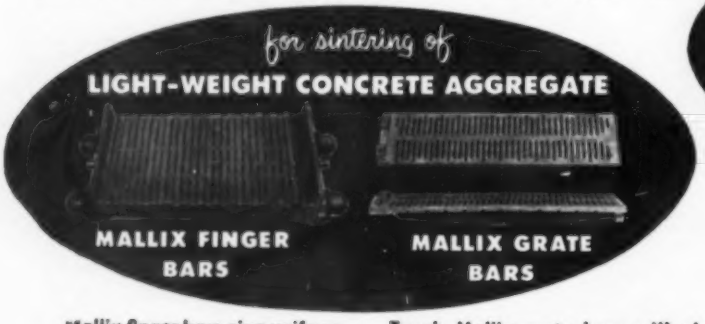

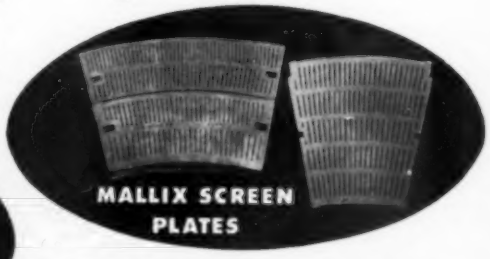

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Continued from page 64

dry air circulation through the cars was eliminated, quality of brick were noticably improved. Kiln cars are advanced through the hacking station with hydraulic pushers operated by the men loading the cars. Room for 36 cars is available in the holding room and as production has been boosted at the plant additional storage for 12 cars has been constructed.

"Additional improvements are to be expected" R. W. Woods Superintendent.

The drier is a two tracked tunnel with very rigid control of both humidity and temperature provided due to the sensitive nature of the raw material. The kiln proper is 250 feet long.

Constant Kiln Temperature

Since the operators have manipulated the blending of the various clays the kiln is able to operate with a constant maturing temperature which is 2170 to 2200 degrees. As the plant produces white, pink, red and black brick, often in short runs the elimination of constant kiln temperature manipulation is credited with being one cause of a high recovery of perfect brick. In addition to the wide range of colors that have been developed at the plant size variations represented in roman and norman size brick add to the complexity of the operation. Normally an hour and forty five minutes schedule is maintained. Recording and control instruments on the kiln are from Brown Instrument Division with a three zone control system using Hauck burners providing accurate conformity to the desired firing curve. Two zones are provided in the furnace section and one in the preheat section. Each control zone consists of 12 burners, six on each side, adjusted for proper balance. The kiln uses a quick cooling zone and has 78 feet of controlled cooling section. Push through the kiln is with a five horse Vickers package hydraulic set up.

Brick Packaged

Fired brick handling has been developed to meet the needs of this particular material and at the same time eliminate as much heavy work as possible. All brick are taken from the kiln cars, placed on roller conveyors that move the brick to cubing stations. The cubing crew acts to grade brick, both as to color and to reject any with other defects and places all good brick into 500 brick Bickerstaff cubes. On completion of each cube the brick are moved to storage with a fork truck. Two five man gangs are used to grade and cube the daily output of 75,000 brick.

Wooden platforms indexed to locate the runner brick of the cubes are used to insure that each cube is of such a size as to be handled by the automatic grippers of the Bickerstaff fork.

Equipment used includes 3 fork trucks for the brick

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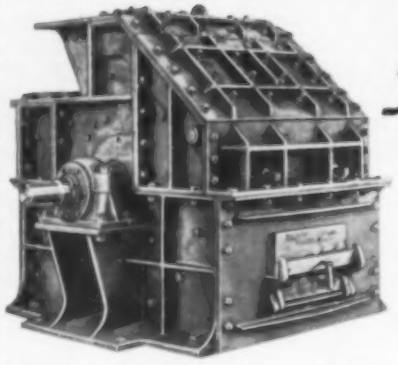

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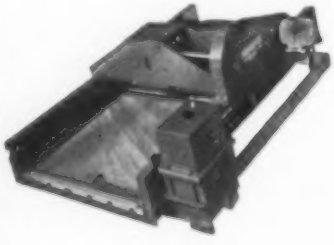

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fractory body and a special shape is more than compensated for in the reduction in handling labor."

With reference to the present market in the ceramic industry—especially the clay products industries—reported by at least 60% of the kilns and furnaces in use in the ceramic industry operate at temperatures below 2300°F. Thermal shock is almost universally a problem with these lower temperature kilns and furnaces. Of the materials generally considered to be resistant to heat shock, perhaps cordierite has enjoyed the distinction of having the lowest expansion. The new refractories are considerably lower in expansion than normal cordierite bodies and, by Robinson's tests, greatly outlast them in actual service.

Silicon carbide also has good thermal shock resistance—not due to a low thermal expansion but rather due to high thermal conductivity. Thermal conductivity permits rapid distribution of heat throughout the refractory piece and thermal stresses do not build up. The extremely low thermal expansion of petalite refractories also defeats thermal stresses, but at substantially less cost.

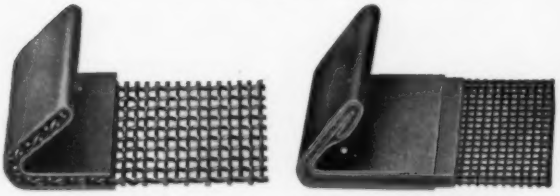
Athens Blends Con't . . .

handling area and 9 trucks for deliveries. Six of the latter are tractor and trailer units with three bob tails used for closer deliveries. Most shipments from the plant are with the truck fleet within a 200 mile radius but some brick are shipped by rail.

While the production rate and recovery has constantly improved since the plant was completed late in 1956 additional improvements are to be expected, according to R. W. Woods who is superintendent at the plant. The overall operations of the company are under the direction of H. B. Sampson, General Manager.

The major buildings at the plant are pipe frame and steel sheated. The tunnel kiln building is 50 x 500 feet and in addition to housing the tunnel kiln, also has room for the holding chambers, off-bearing station, grading and cubing activities. The mill room building measures 50 x 75 feet and preliminary crushed clay is housed in a building measuring 90 x 140 feet. Other minor buildings are used for loading shelter and office space.

Tyler Screen Sections for All Makes of Screening Machines!



Screen sections of Tyler Woven Wire are fabricated for all makes of vibrating screens in any mesh or metal. They are made up with hook-strip or bent-edge construction to suit the machine on which they are to be used.

Tyler rugged, accurately-applied hook-strips make possible stretching and maintaining the screens at drum-head tension, which is essential for successful screening and long screen life.

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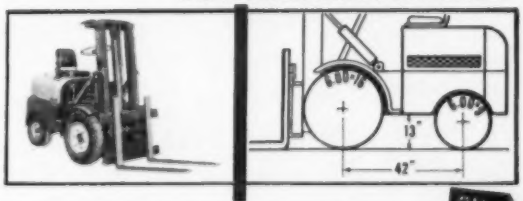

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(*Continued from page* 80)

3. Three high kiln settings are possible on an open grillage car deck.
4. Block can be loaded two high in a roller hearth kiln.

Compressive tests made on various block gave generally low and erratic results. The best compressive test for the periodic firings was 1210 psi for expanded-shale aggregate mix and 230 psi for the SCR aggregate mix. For the tunnel kiln firings highs of 500, 630 and 680 psi were obtained for Haydite-type aggregate mixes and 190 psi for SCR aggregate mix. Cold water absorption tests gave generally high percentages with the best results at 17.3% for an expanded-shale aggregate mix and 13.6% for an SCR aggregate mix. Block weights were low with 21# and 15# respectively for expanded-shale block and SCR block. The block showed no soluble staining or effloresecing salts. Freezing and thawing tests and autoclave tests indicated excellent weathering resistance. The over-all results could be generally considered as promising.

Equipment selection and plant layout depend mainly on the product objective, available aggregate type and method of forming.

Slurry Mixing

Expanded shale aggregates are usually associated with vibration compaction and possible pneumatic impact pressing. A modified concrete block plant layout would work here. The slurry approach to mixing should be used, with a clay-water slurry prepared by high speed propeller type mixer and metered into the aggregate at the ribbon mixer.

Because of the high production rate of most concrete block machines and the maintenance and clean-up requirements they would be operated on a periodic basis. Block could be racked for surge storage using the same equipment standard to uncured concrete block handling. Since block are discharged from the forming machine on flat steel pallets and with poor wet-green strength, they must be dried on these pallets. Because of the green strength-moisture content relationship there is no point in removing the block from the pallet until it has developed dry strength enough for handling to firing. The setting pattern will generally determine this point.

Drying can be accomplished in batch dryers taking full racks or shelf type continuous dryers loaded with the flat steel pallets. The solid steel pallet will impede air circulation and requires special air moving techniques. The block are stripped from these pallets for kiln firing. At the exit end of the kiln, block are cubed for storage or shipment.

SCR aggregate mixes can be processed to block as previously stated or formed by dry pressing. Dry pressing is essentially a continuous operation and can be tied into drying and firing. Since direct firing seems possible—except when block are glazed—the block can be loaded directly into the kiln. The dry batch method of mixing should be used to prepare the mixture for dry pressing. Fired block are cubed near the exit end of kiln.

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OL 3-2360

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Also new International Hydraulic Toggle Drive Press for face brick, refractory brick and shapes. Write for descriptive literature and prices.

FERNHOLTZ MACHINERY CO., 8468 MELROSE PLACE, LOS ANGELES 46, CALIFORNIA

Steele's Test Plant Is at Your Service

Here are several views of Steele's completely equipped full scale test plant. This plant renders you valuable free services which help solve your problems and save you money. Here are some of the functions of this plant.

1. Make full scale tests of your own materials under actual working conditions. This service has been found valuable by clay working plants as far away as South Africa and Australia.
2. Make complete tests of all new equipment designs and innovations before actually putting a machine into a production plant. Steele takes the "bugs" out of all new type equipment before offering it for sale.
3. Make demonstrations of various items of Steele equipment for prospective purchasers.

Steele's Engineering Department draws on almost 70 years of practical experience to improve existing equipment or to design special machines to meet unusual conditions.

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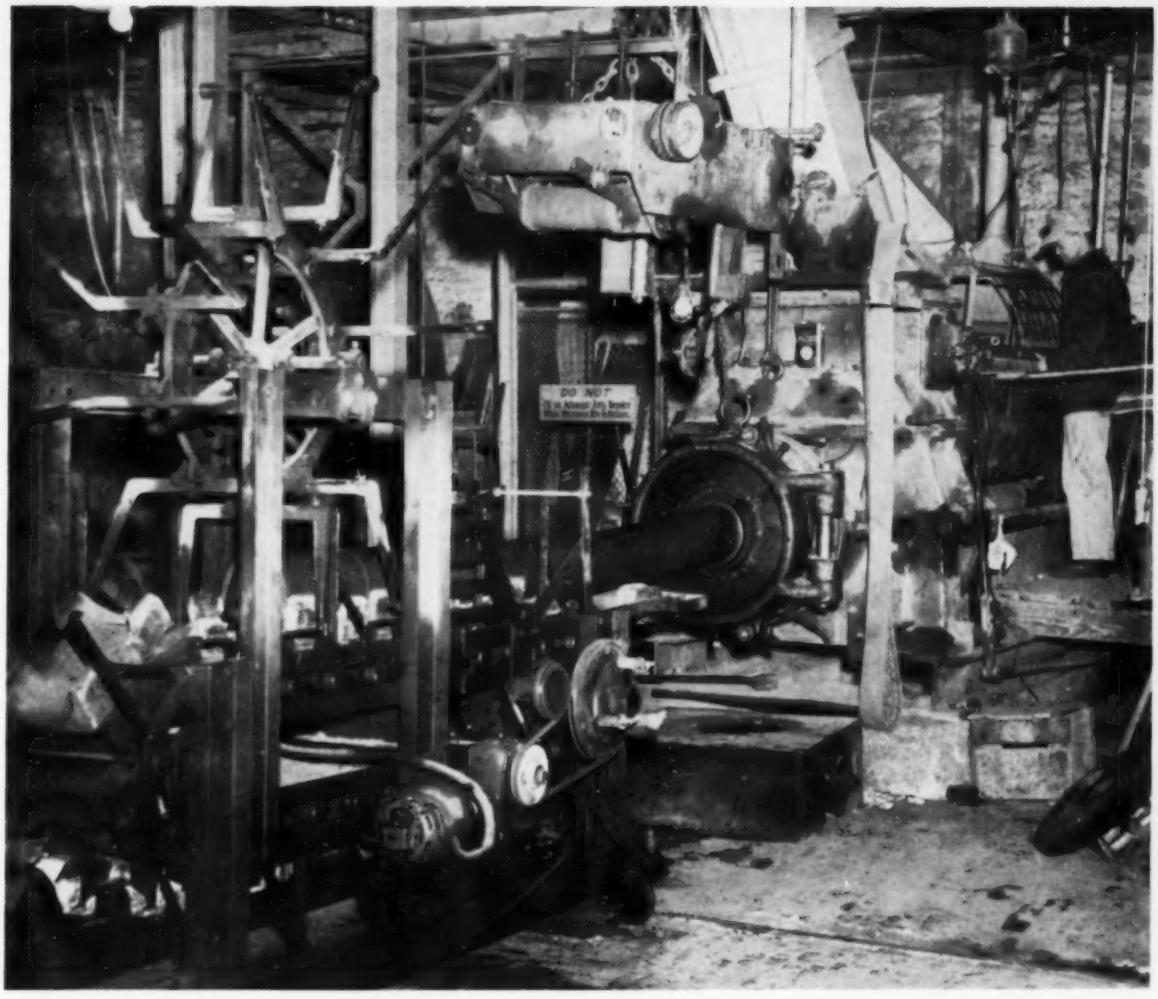

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